# INTRODUCTION TO CFD

**PROF. ARNAB ROY**
Department of Aerospace Engineering
IIT Kharagpur

**PRE-REQUISITES :** Basic course on Fluid Mechanics and Numerical Methods

**INTENDED AUDIENCE :** Aerospace Engineering/ Mechanical Engineering/ Applied Mechanics/ Applied Mathematics and allied disciplines

**INDUSTRY SUPPORT :** This introductory course on computational fluid dynamics (CFD) could be appropriate for new recruits in aerospace research laboratories like NAL, DRDL, ADA, ADE, HAL and private industry like Boeing and Airbus.

**COURSE OUTLINE :**

This course is introductory in nature and expected to impart firsthand knowledge of CFD. It is mainly aimed for senior undergraduate students/ first year post graduate students in Aerospace, Mechanical, Applied Mechanics, Applied Mathematics and allied streams. It is concerned with application of numerical methods for solving conservation equations of fluid dynamics. The subject will be taught with the objective of motivating students to develop their own computer codes. With a long experience of teaching both introductory and advanced courses in CFD to UG, PG and PhD students, I strongly feel that this is the best way to learn CFD.

**ABOUT INSTRUCTOR :**

Prof. Arnab Roy is currently working as Professor at the Department of Aerospace Engineering, IIT Kharagpur. His official webpage is: http://www.iitkgp.ac.in/department/AE/faculty/ae-arnab. He has taught various courses covering Aerodynamics, introductory and advanced courses in CFD, Wind Tunnel Design and Testing as well as a few courses in Aerospace Propulsion at IIT Kharagpur to UG/ PG and PhD students.On almost all occasions he has received an overall student feedback rating between 4 and 5 (on a scale of 5). In all, he has about 18 years teaching experience at UG, PG and PhD levels combined. His research interests include computational and experimental fluid dynamics. He am also involved in aerospace propulsion research. He has undertaken and executed projects for different organizations like AOARD (Japan), Boeing (USA), AR&DB, DLJ-DRDO, RDSO, ISRO, DST etc. He has delivered several CFD related invited lectures at GE Aviation JFWTC, Bangalore (2019); CFD Workshop, BITS Pilani Hyderabad campus (2016); 13th Aeronautical Society of India Annual CFD Symposium at IISc Bangalore (2011),Indo US INDUS-MAV Workshop at Bangalore,organized by NAL and ADE Bangalore (2009) etc.

**COURSE PLAN :**

**Week 1:** Governing conservations equations of fluid flow and classification of system of partial differential equations (PDEs)

**Week 2:** Methods for approximate solution of PDEs: brief overview of finite difference, finite volume and finite element approaches

**Week 3:** Taylor table approach for constructing finite difference schemes of arbitrary orders of accuracy, implementation of schemes near boundaries

**Week 4:** Numerical solution of steady state heat conduction (Elliptic PDE) using various explicit and implicit schemes, implementation of boundary conditions, mesh dependence and convergence of solution

**Week 5:** Numerical solution of unsteady heat conduction (Parabolic PDE) using various schemes, implementing initial and boundary conditions, stability analysis, multi-dimensional implementation

**Week 6:** Numerical solution of linear wave equation (Hyperbolic PDE) using various schemes, artificial viscosity, diffusion and dispersion error, stability analysis

**Week 7:** Numerical solution of one dimensional convection-diffusion equation

**Week 8:** Numerical solution of two dimensional incompressible Navier Stokes equations

**Week 9:** Numerical solution of one dimensional Euler equation for shock tube problem

**Week 10:**Basics of interface capturing methods for application in multiphase flow

**Week 11:**Basics of turbulence modeling

**Week 12:**Structured and unstructured grid generation