# **CFD for Turbomachinery**

## **Prof. B V S S S Prasad**

Department of Mechanical Engineering, IIT Madras

### **Prof. Y V S S Sanyasiraju** Department of Mathematics, IIT Madras

#### **Module 1 Governing Equations**

Lecture 1.0 Orientation to the Course
---------------------------------------

<u>Lecture 1.1</u> Introduction to Fluid Dynamics

Lecture 1.2 Blade Element Theory

Lecture 1.3 Governing Equations in a Stationary Frame of Reference (Viscous Flows)

Lecture 1.4

Governing Equations in Stationary Frame of Reference (Inviscid Flows)

Lecture 1.5	Governing Equations in Rotating Frame of Reference (Inviscid and Viscous Flows)
Lecture 1.6	Passage Averaged Equations and Turbomachinery Blade Design
Lecture 1.7	Reynolds Averaged and Filtered Navier – Stokes Equations
Lecture 1.8	RANS Turbulence Modelling – 1
Lecture 1.9	RANS Turbulence Modelling – 2

#### **Module 2 Solids Modelling**

Lecture 2.2 Cubic Splines

Lecture 2.3 Surfaces

Lecture 2.4

Illustration

#### **Module 3 Mesh Generation**

- Lecture 3.1 Introduction
- <u>Lecture 3.2</u> Methods for Structured Mesh Generation
- <u>Lecture 3.3</u> Successive Layer Grid Generation
- <u>Lecture 3.4</u> Differential Equation Based Schemes
- Lecture 3.5 Control Functions and Adaptive Grid Generation
- Lecture 3.6 Unstructured Mesh Generation
- Lecture 3.7 Hybrid Grids and Grid Independence Study

#### **Module 4 Computational Methods**

**Classification of PDE** Lecture 4.1 Lecture 4.2 Finite Difference Approximation Lecture 4.3 **Higher Order Approximations** Lecture 4.4 Schemes for Elliptic Type Equations Lecture 4.5 Schemes for Parabolic Type Equations Lecture 4.6 Schemes for Hyperbolic Type Equations

Lecture 4.7	Finite Volume Discretization								
Lecture 4.8	Numerical Illustrations								
Lecture 4.9	Finite Volume Method with Structured and Unstructured Grids								

#### **Module 5 Solvers**

Lecture 5.1 Solving Linear System of Equations

<u>Lecture 5.2</u> Iterative Methods

Lecture 5.3 Numerical Schemes for Incompressible Flow Equations

Lecture 5.4 Methods based on Coupling of Pressure and Velocity

Lecture 5.5 Incompressible Flow Solvers

#### Lecture 5.6 Numerical Illustration

<u>Lecture 5.7</u> Compressible Euler Equations

<u>Lecture 5.8</u> Flux Vector Splitting

#### **Module 6 Case Studies**

- Lecture 6.1 A CFD Code for Turbomachinery Flows
- Lecture 6.2 Internal Inviscid Flows
- Lecture 6.3 Transonic Flow Through a NACA0012 Airfoil Cascade
- Lecture 6.4 Unsteady Flow Evolution in a Channel by a Step
- Lecture 6.5 Turbine Cascade
- Lecture 6.6 Interacting Stator and Rotor Cascades-Inviscid flow

Lecture 6.7	Inviscid	Subsonic	Flow	of	a	One	and	Half
	Stage Ax	kial Turbin	e					

Lecture 6.8Inviscid Subsonic Flow of a One and HalfStage Axial Turbine

Lecture 6.9 Inviscid Transonic Flow of a Single Stage Axial Turbine

Lecture 6.10 Unsteady Turbulent Flow of a Single Stage Transonic Axial Turbine

Lecture 6.11 Inverse Design of a Compressor Cascade

**Bibliography**