

# Introduction to Computational Fluid Dynamics using OpenFOAM and Octave

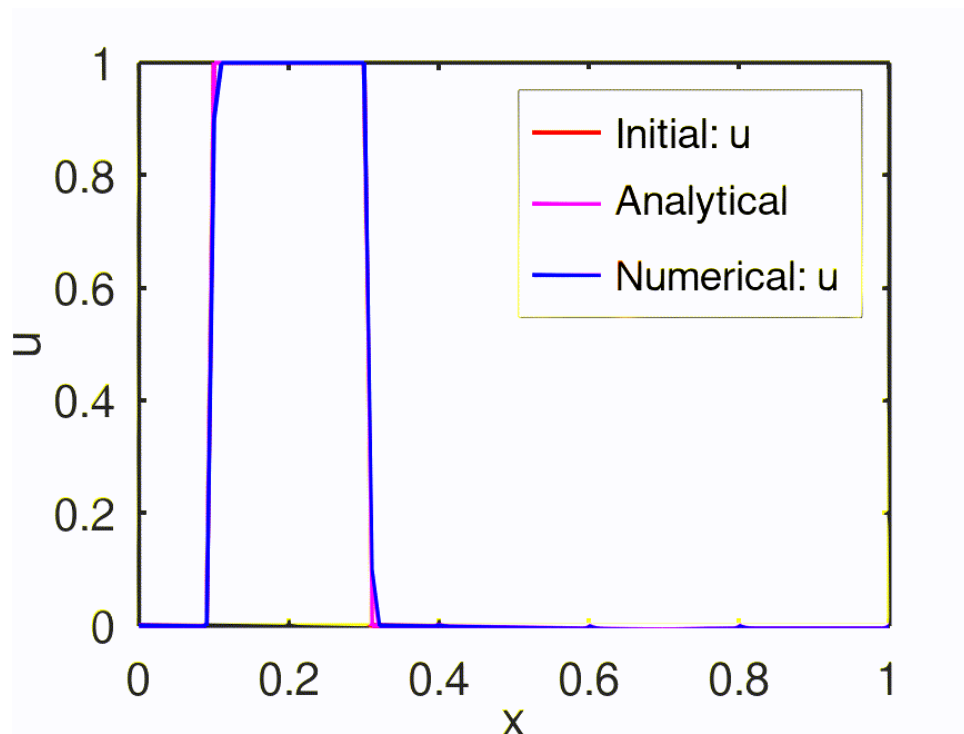
Dr. Lakshman Anumolu (Sr. Research Engineer)  
Kumaresh Selvakumar (PhD candidate)  
(Session-8)

*Instructions: Mon, Wed, Thu (5:30PM-6:30PM IST)*  
*Query session: Sundays 8AM-8:30AM IST*

# Quick Recap

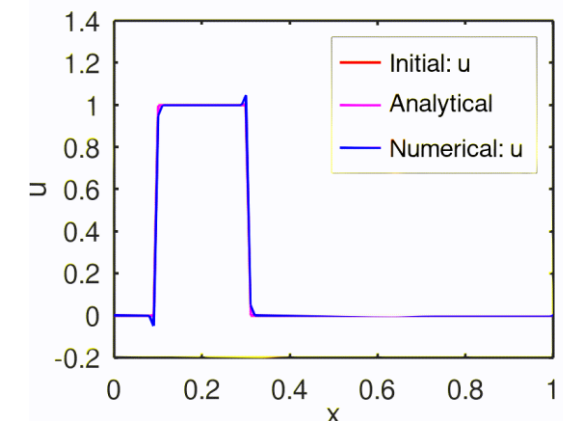
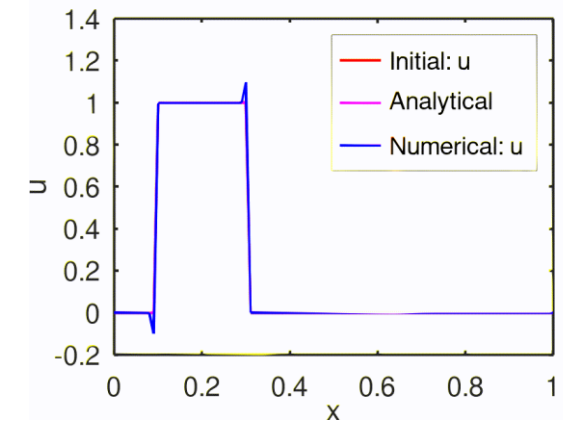
# What Did We Discuss?

$$u_i^{n+1} = u_i^n - c\Delta t \left( \frac{\partial u}{\partial x} \right)_i^n \longrightarrow \left( \frac{\partial u}{\partial x} \right)_i^n \approx \frac{u_i^n - u_{i-1}^n}{\Delta x_i} \quad \text{Upwind}$$



$$\left( \frac{\partial u}{\partial x} \right)_i^n \approx \frac{u_{i+1}^n - u_i^n}{\Delta x_i} \quad \text{Simple forward difference scheme}$$

$$\left( \frac{\partial u}{\partial x} \right)_i^n \approx \frac{u_{i+1}^n - u_{i-1}^n}{2\Delta x_i} \quad \text{Central difference}$$

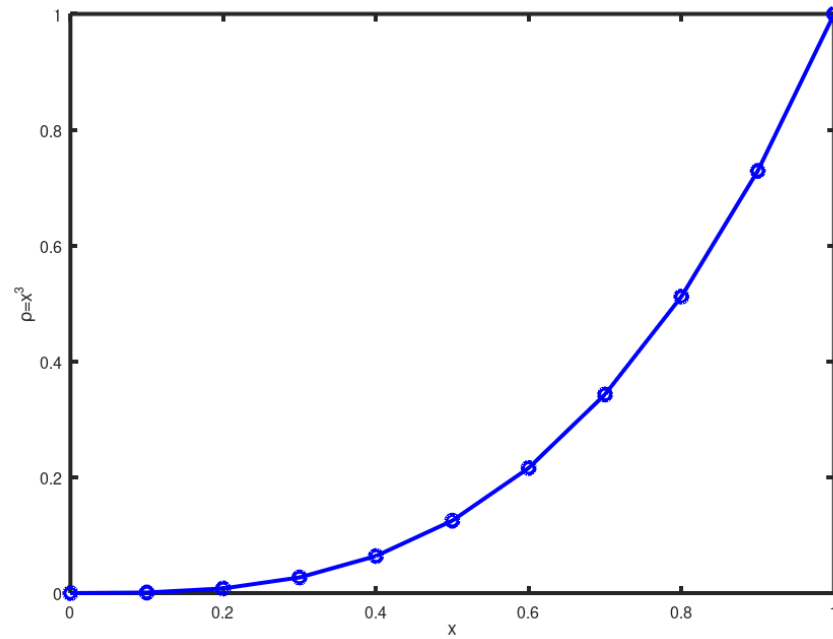


# Current Session

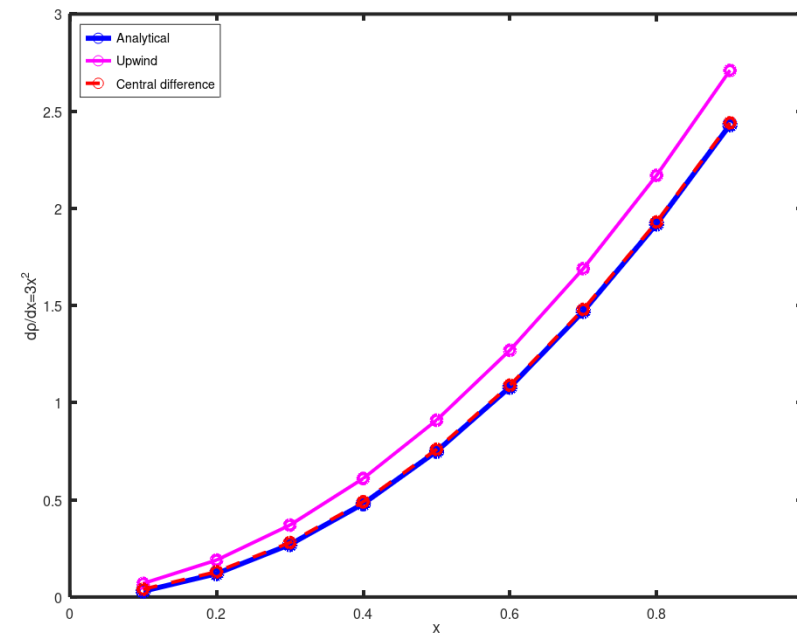
# Overview

- Rate of convergence
- Introduction to C++ for OpenFOAM

# Rate of Convergence

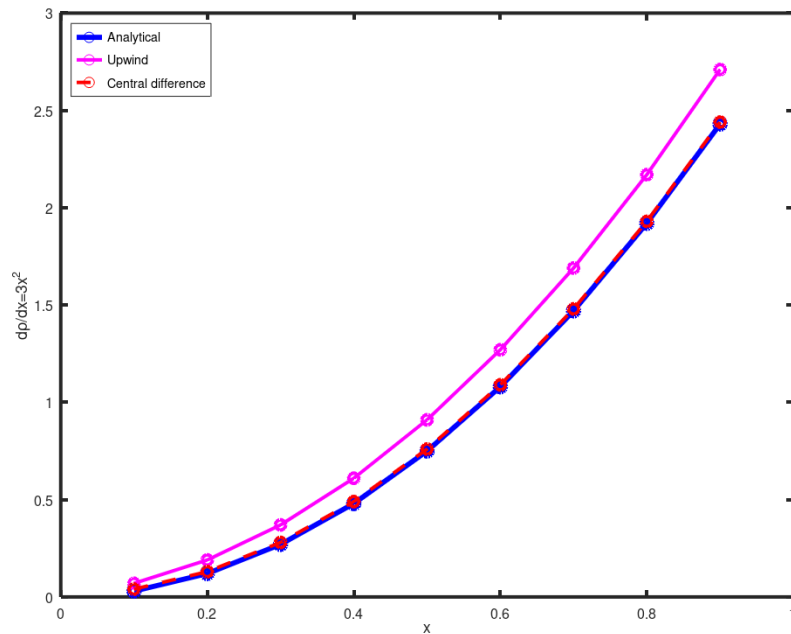


$$\rho = x^3$$



$$\frac{\partial \rho}{\partial x} = 3x^2$$

# Rate of Convergence



$$\frac{\partial \rho}{\partial x} = 3x^2$$

First order forward difference approximation

$$\left(\frac{d\rho}{dx}\right)_i \approx \frac{\rho(x_{i+1}) - \rho(x_i)}{\Delta x_i} + O(\Delta x_i)$$

Second order central difference approximation

$$\left(\frac{d\rho}{dx}\right)_i = \frac{\rho(x_{i+1}) - \rho(x_{i-1}))}{2\Delta x_i} + O(\Delta x_i^2)$$

# Rate of Convergence



$$\left(\frac{d\rho}{dx}\right)_i \approx \frac{\rho(x_{i+1}) - \rho(x_i)}{\Delta x_i} + O(\Delta x_i)$$

$\Delta x$	Error	Rate of convergence
0.1	0.16	-
0.05	0.0775	1.04
0.025	0.038125	1.02

$$\left(\frac{d\rho}{dx}\right)_i = \frac{\rho(x_{i+1}) - \rho(x_{i-1}))}{2\Delta x_i} + O(\Delta x_i^2)$$

$\Delta x$	Error	Rate of convergence
0.1	0.01	-
0.05	0.0025	2
0.025	0.000625	2



# Rate of Convergence



$$\left(\frac{d\rho}{dx}\right)_i \approx \frac{\rho(x_{i+1}) - \rho(x_i)}{\Delta x_i} + \mathcal{O}(\Delta x_i)$$

$\Delta x$	Error	Rate of convergence
0.1	0.16	-
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$$\left(\frac{d\rho}{dx}\right)_i = \frac{\rho(x_{i+1}) - \rho(x_{i-1}))}{2\Delta x_i} + \mathcal{O}(\Delta x_i^2)$$

$\Delta x$	Error	Rate of convergence
0.1	0.01	-
0.05	0.0025	2
0.025	0.000625	2

# Introduction to C++ for OpenFOAM

*b8\_functions\_classes.cpp*

# Next Session

- Finite difference method to solve diffusion equation
- Introduction to C++ for OpenFOAM

Thank you