Applied Computational Fluid Dynamics Using OpenFOAM

Day - 5

Value Added Course
College/University: AEC
Spring 2025

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Develop = Guide = Collab

Contents

- Solving Convection Equation in OpenFOAM
- Project – 2

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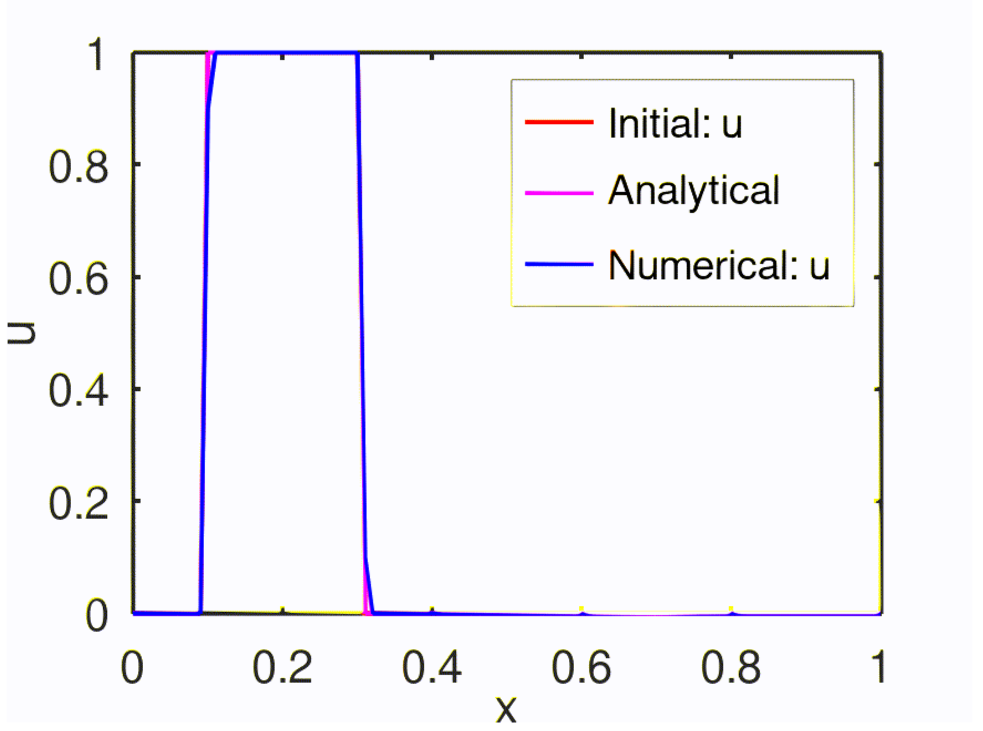
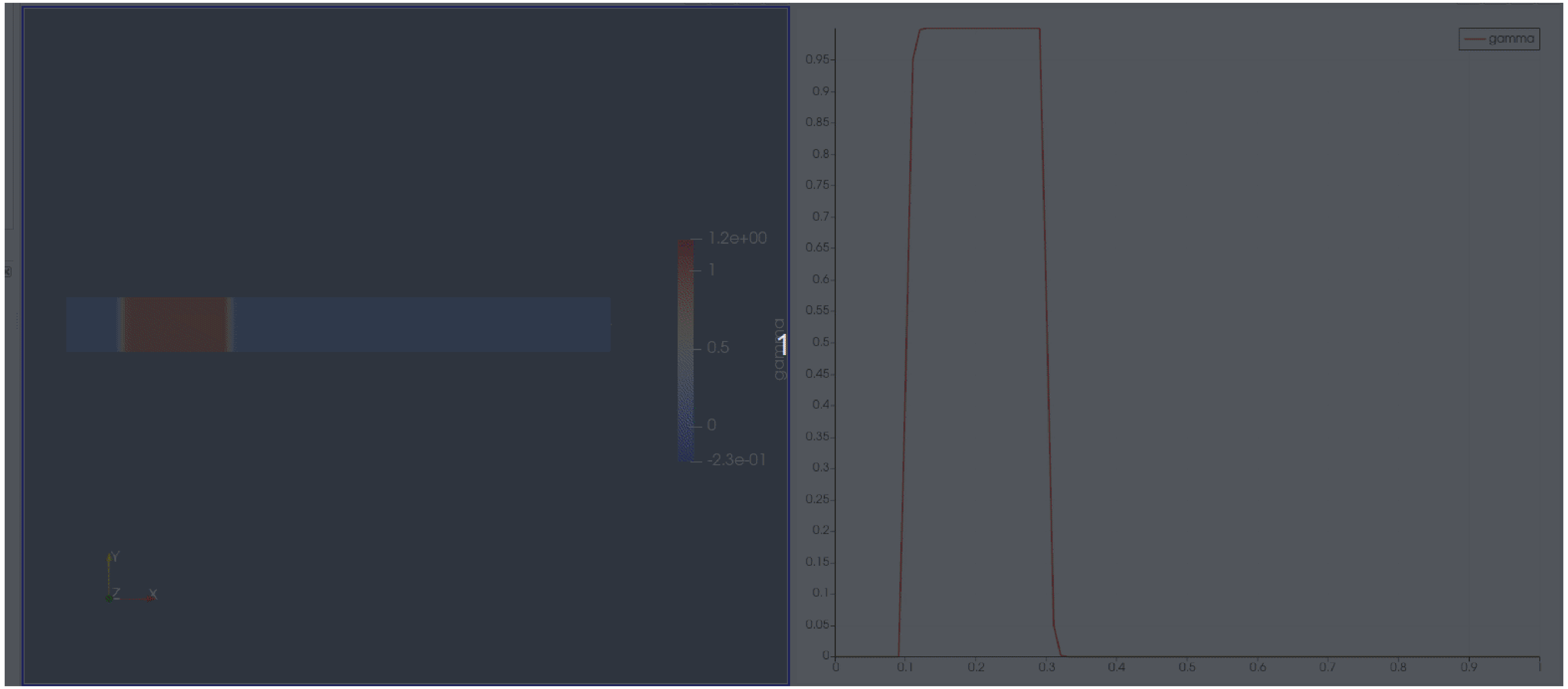
OpenFOAM: Numerical Solution to Convection Equation



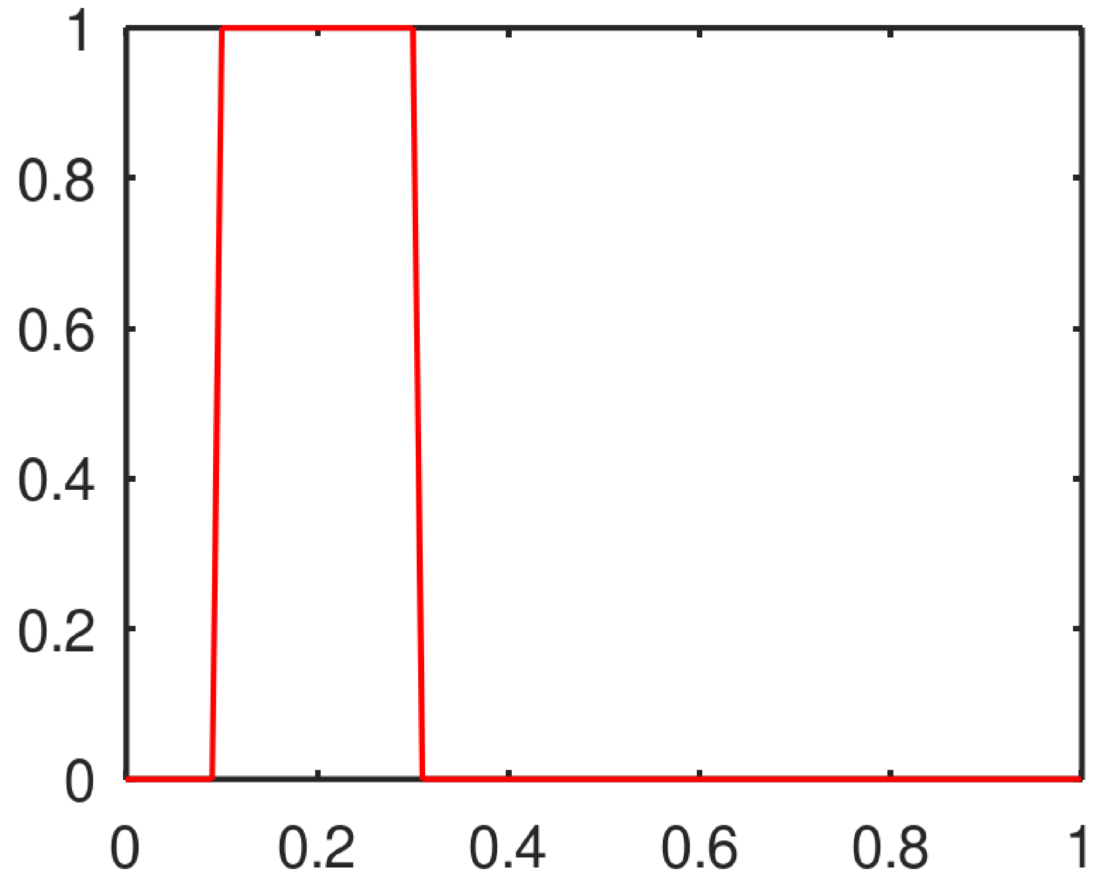


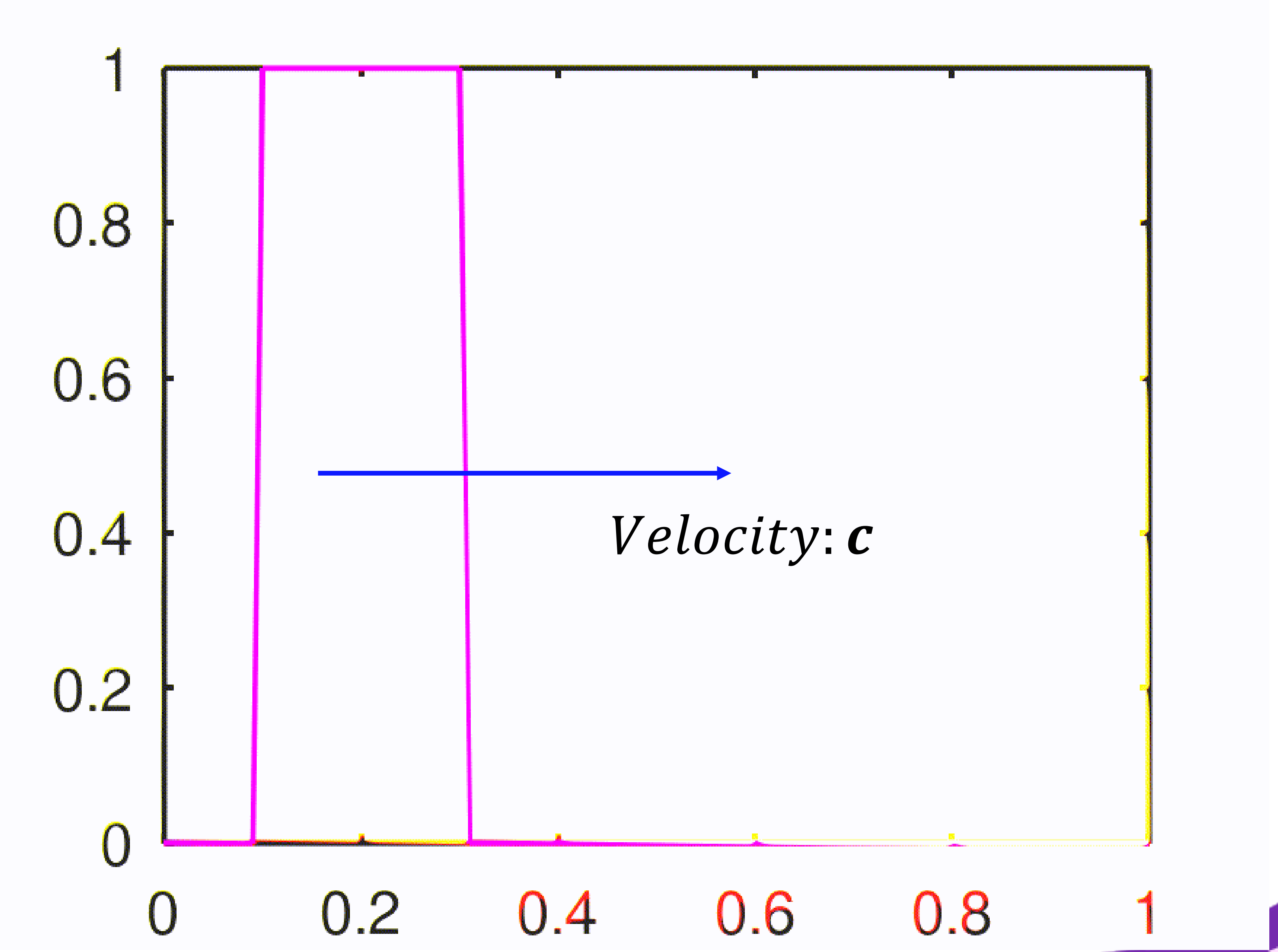
$$\frac{\partial u}{\partial t} + c\frac{\partial u}{\partial x} = 0$$

Convection Equation

Setting initial field

```
for i = 1 : length(x)
  if (x(i, 1) >= 0.1) && (x(i, 1) <= 0.3)
    u(i, 1) = 1;
  endif
end
```

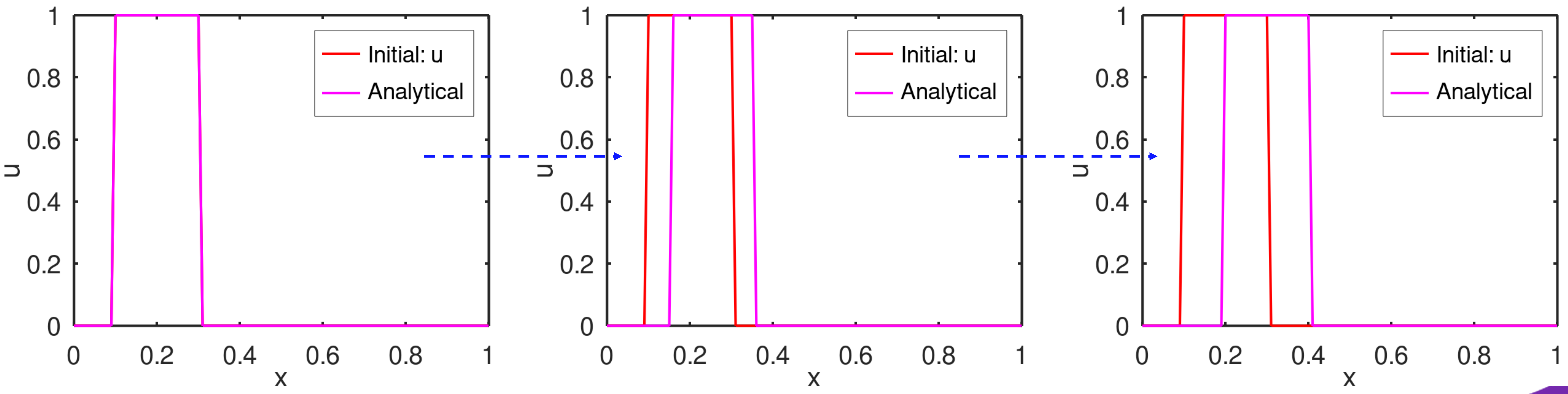




Convection Equation

$$\frac{\partial u}{\partial t} + c\frac{\partial u}{\partial x} = 0$$ ← Advection equation

```
for i = 1 : length(x)
  if (x(i, 1) >= 0.1+c*t) && (x(i, 1) <= 0.3+c*t)
    u_analytical(i, 1) = 1;
  endif
end
```



Convection Equation

$$\boxed{\frac{\partial u}{\partial t} + c\frac{\partial u}{\partial x} = 0}$$

$$\boxed{\frac{u_i^{n+1} - u_i^n}{\Delta t} + c\left(\frac{\partial u}{\partial x}\right)_i^n = 0}$$

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

$$u_i^{n+1} = u_i^n - c\Delta t\left(\frac{\partial u}{\partial x}\right)_i^n$$

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

Simple forward difference scheme

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

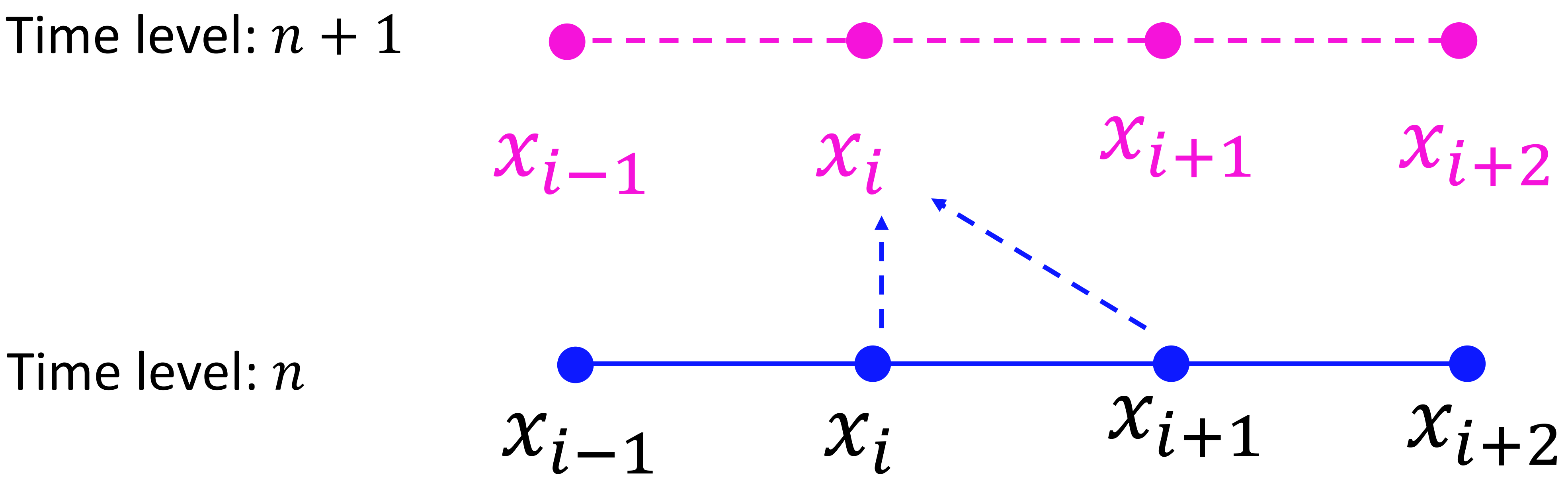
Central difference

(Explicit) First order - Forward Euler

(only one unknown (n+1) with other knowns at n^{th} node)

→ conditionally stable

Convection Equation

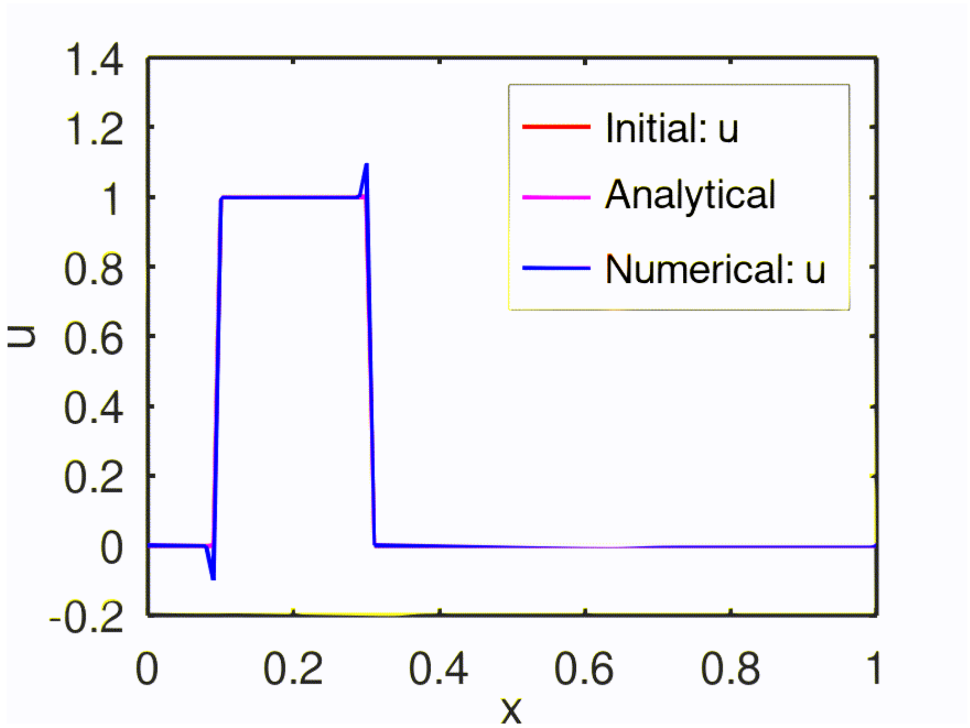


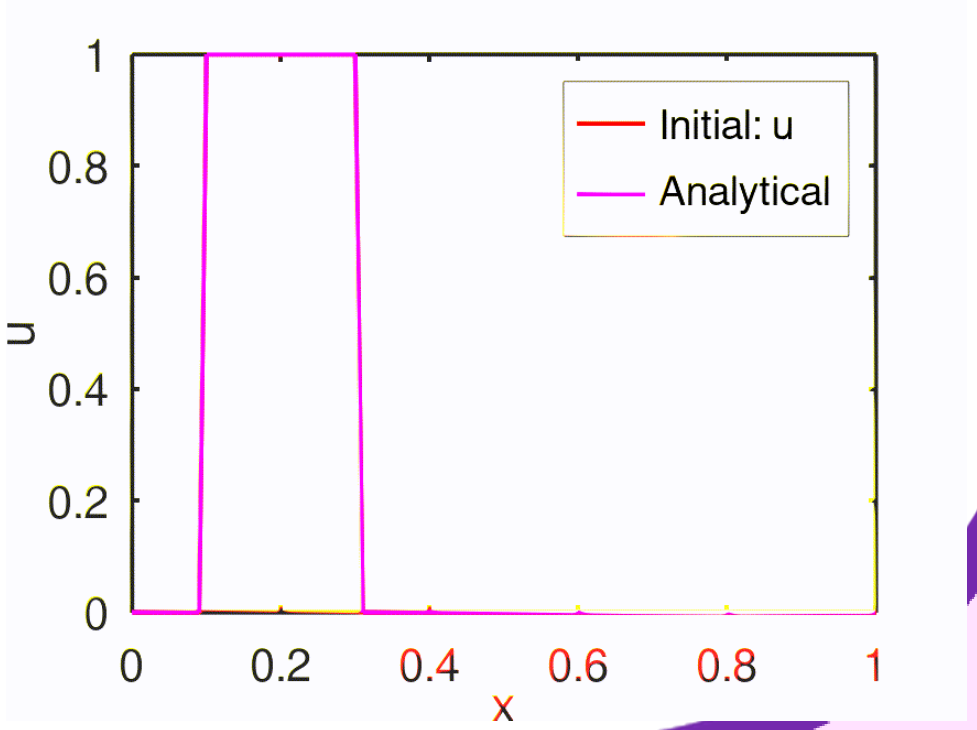
Information from right to left end

$$u_i^{n+1} = u_i^n - c\Delta t \boxed{\left(\frac{\partial u}{\partial x}\right)_i^n}$$

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

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





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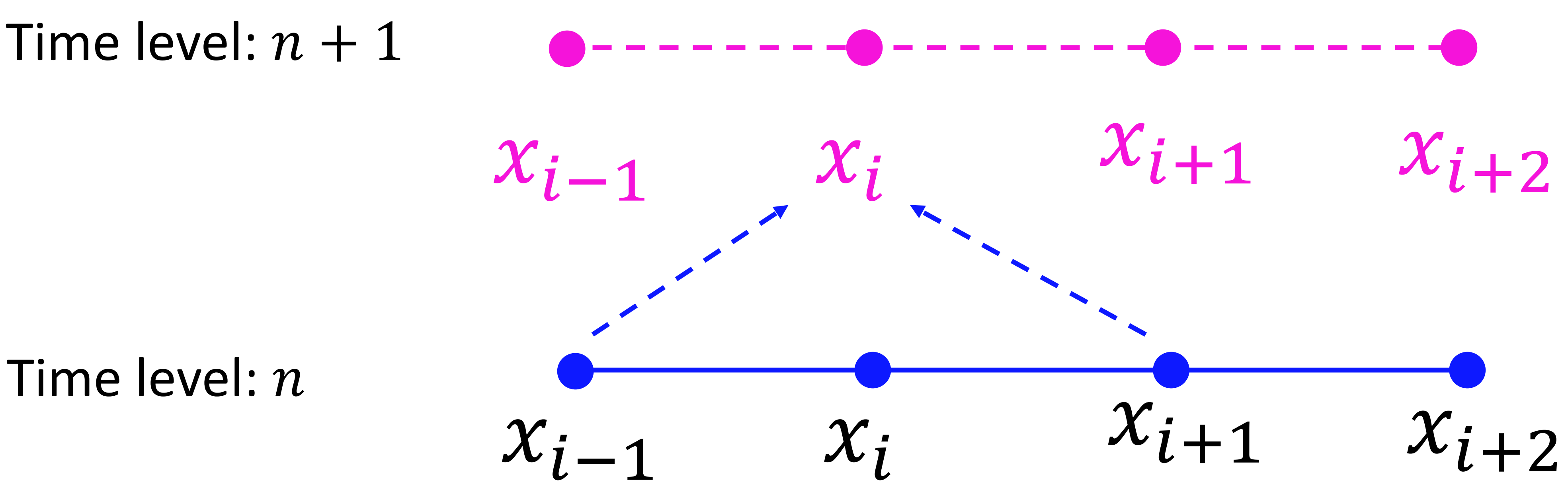
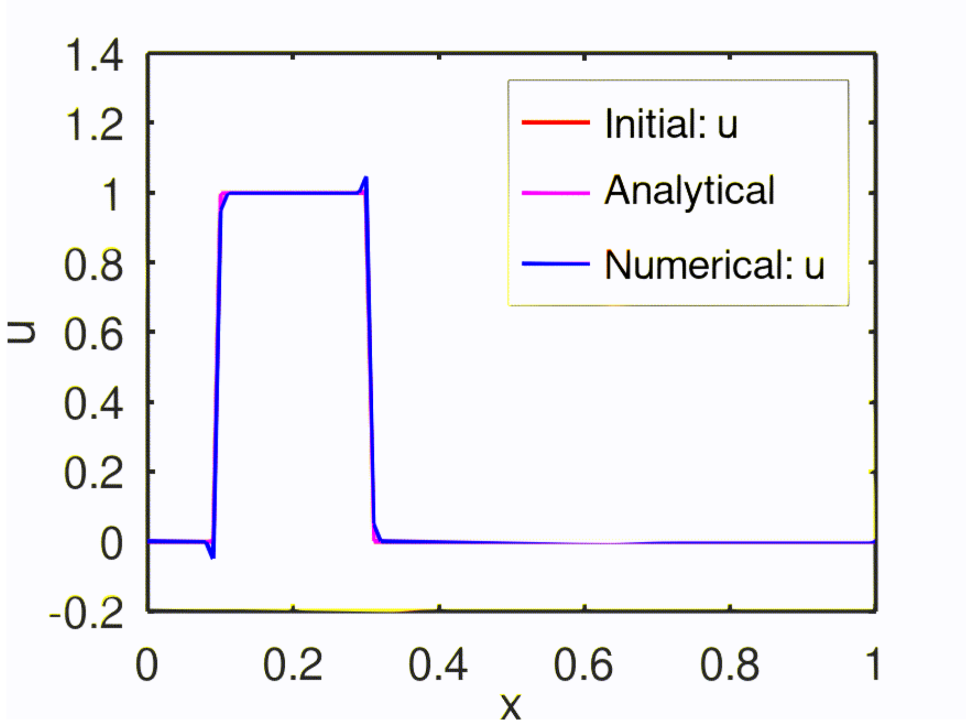
Convection Equation





Information from left and right ends

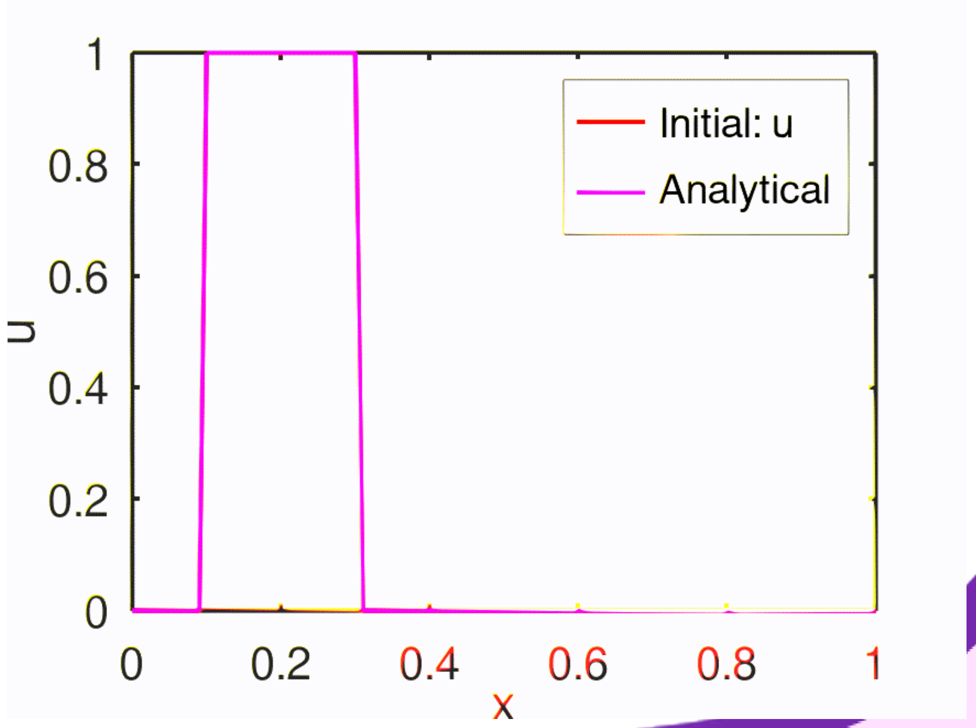
$$u_i^{n+1} = u_i^n - c\Delta t \boxed{\left(\frac{\partial u}{\partial x}\right)_i^n}$$

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

Simple forward difference scheme

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

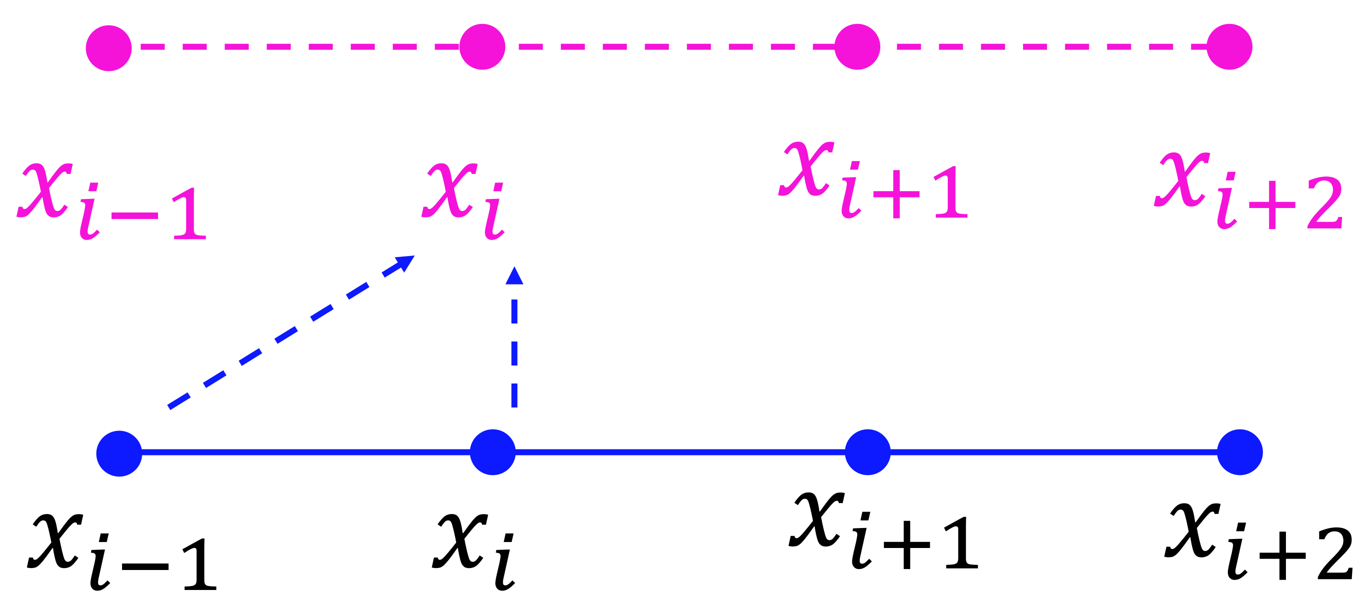
Central difference



Convection Equation

Time level: $n + 1$

Time level: n



Information from left to right end

Wind is flowing from left end (bird moves from left to right)

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

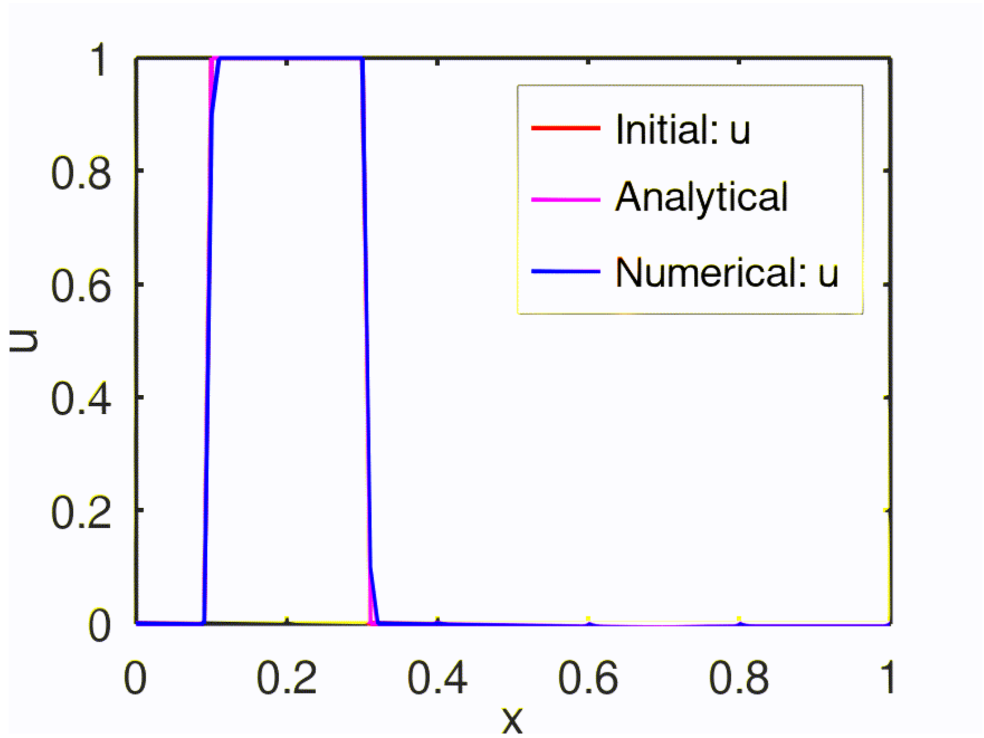
Simple backward difference scheme

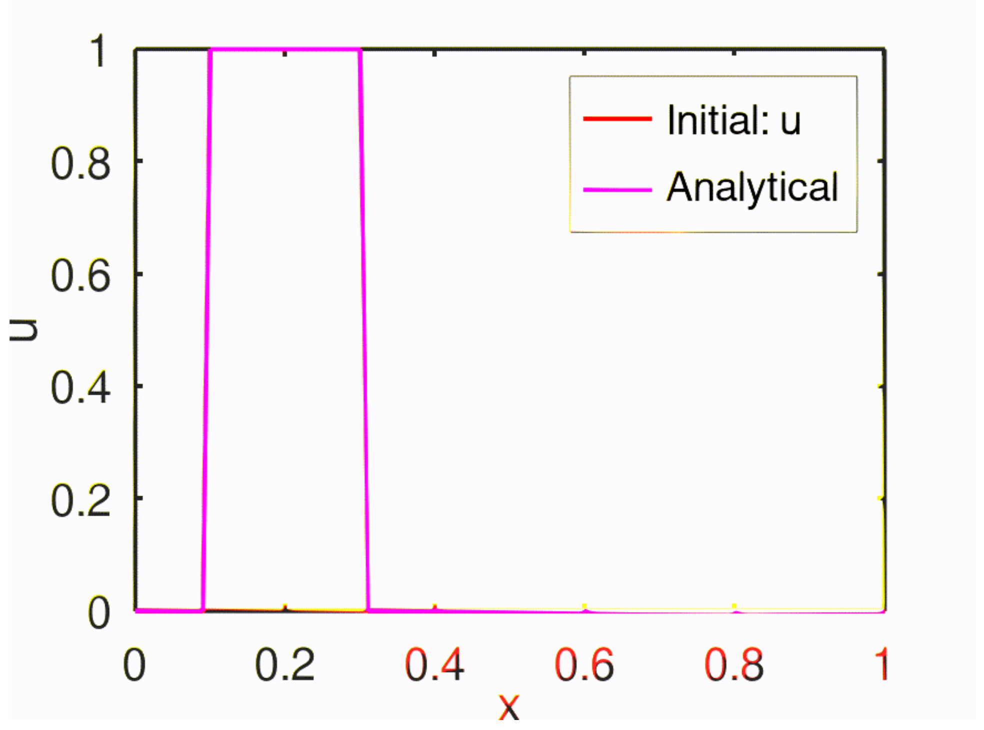
CFL = 0.1

$$CFL: \frac{c\Delta t}{\Delta x}$$

CFL < 1 → Numerically stable (conditionally stable based on the condition imposed by CFL) – EXPLICIT method

CFL > = 1 → Numerically unstable





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$$\frac{\partial u}{\partial t} + c\frac{\partial u}{\partial x} = 0$$

Project 2 - Solving convection equation in OpenFOAM #11

kummi0402 started this conversation in General

kummi0402 2 weeks ago Maintainer

edited

> Make sure OpenFOAM is installed on your systems.
> Install ParaView.
> Copy solver and test case to the working directory.
> Build/compile the solver.

1. wclean
2. wmake

> Run the test case by using following commands:

1. blockMesh
2. setFields
3. simpleConvection
4. touch a.foam

> Visualize the results.
> Share screenshots of results here with clear description

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THANK YOU