Computational Thermal Engineering

Day - 8

ExaSlate

Develop = Guide = Collab

Quick Recap

$$\frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial x^2}$$

OpenFOAM → Project – 1

Project - 1 : Solving Diffusion equation using OpenFOAM #9

kummi0402 started this conversation in General

kummi0402 yesterday Maintainer

Based on day-7 presentation, repeat all steps we discussed during the session

- Make sure OpenFOAM is installed on your systems.
- Install ParaView.
- Copy solver and test case to the working directory.
- Build/compile the solver.
- Run the test case.
- Visualize the results.
- Share screenshots of results here.

1

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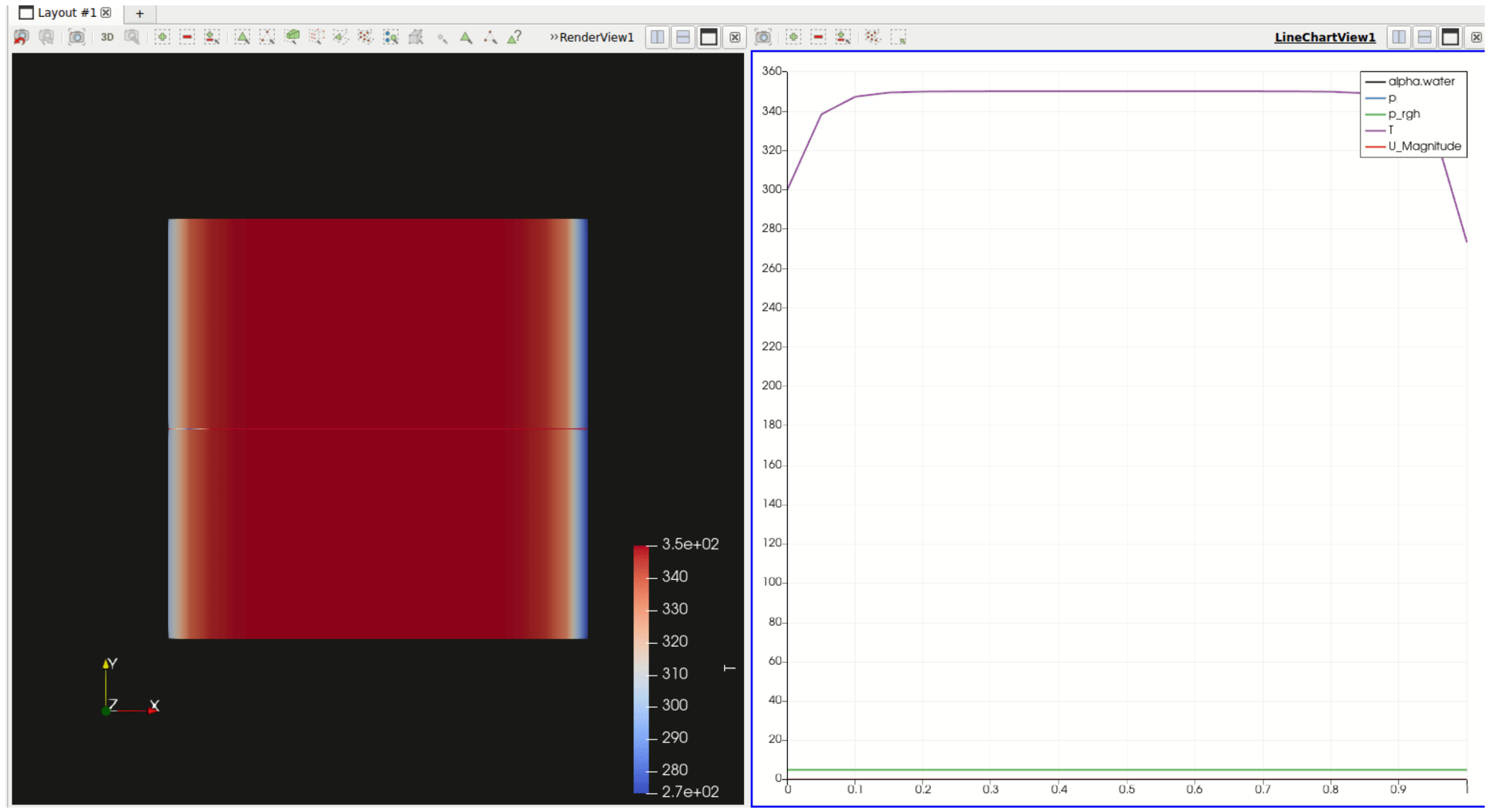

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- Solving Convection Equation in OpenFOAM
- Project – 2

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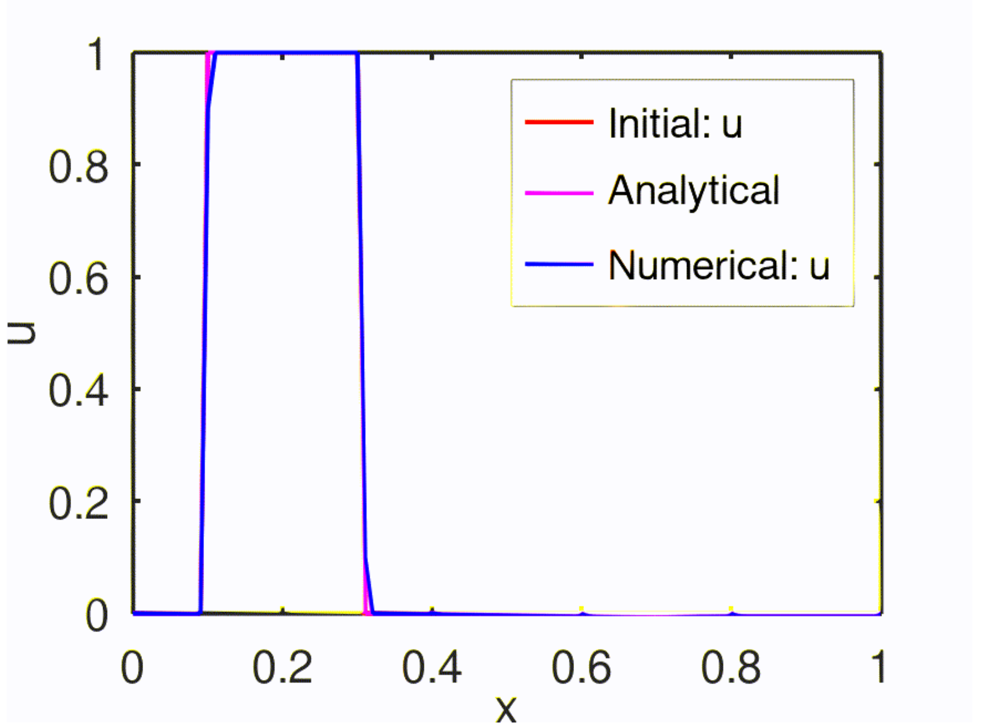
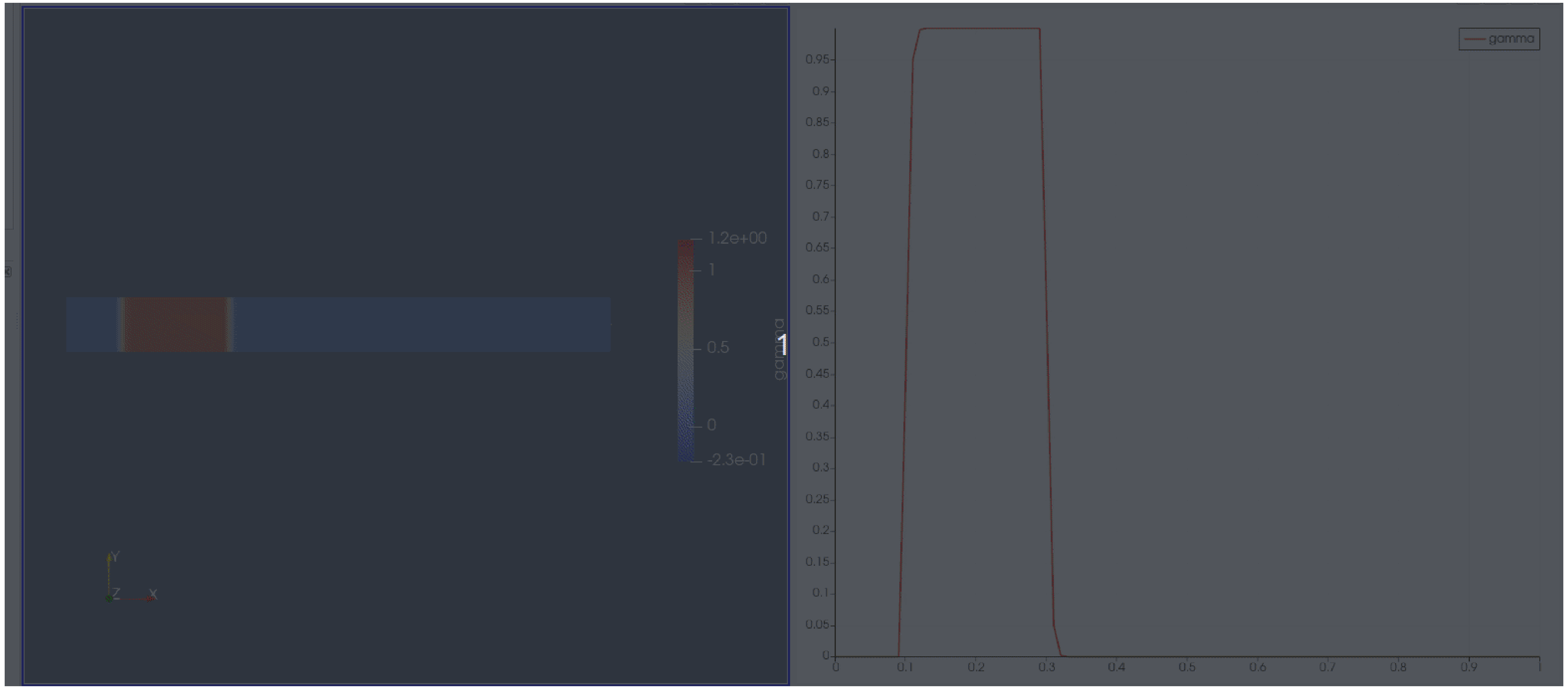
OpenFOAM: Numerical Solution to Convection Equation





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

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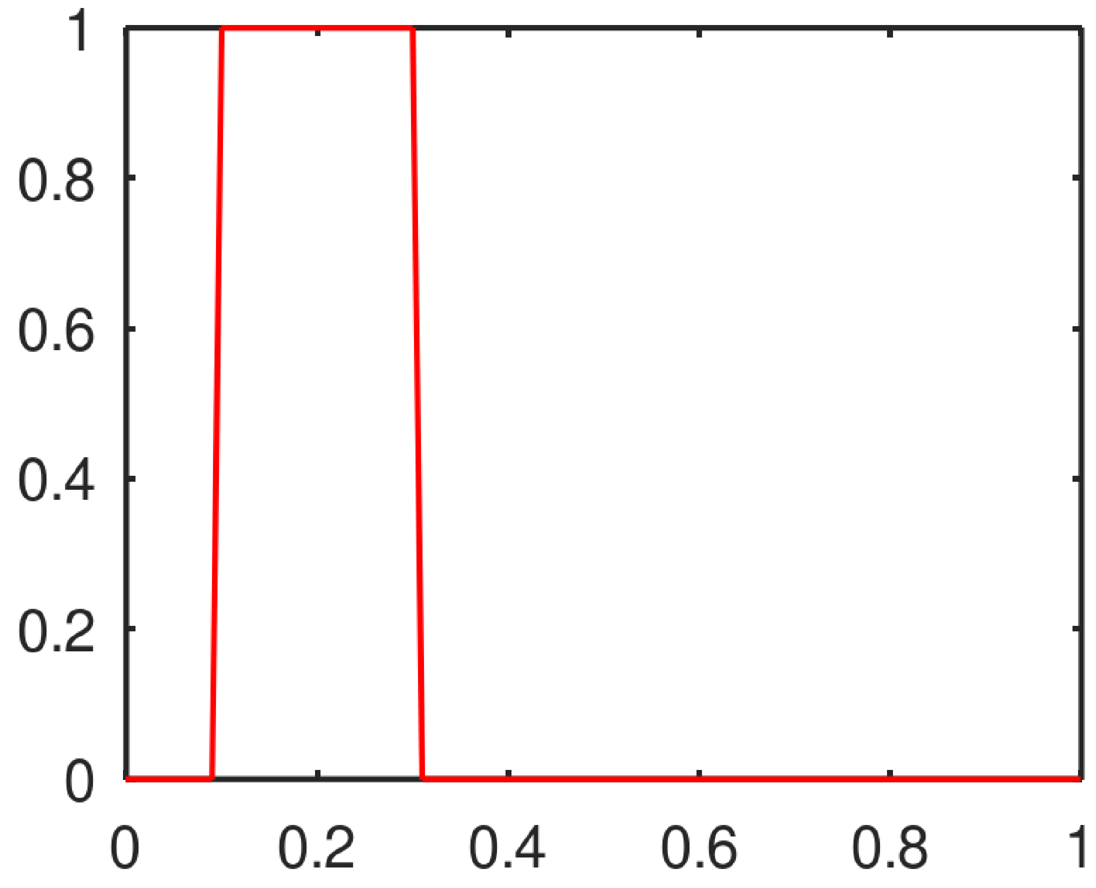
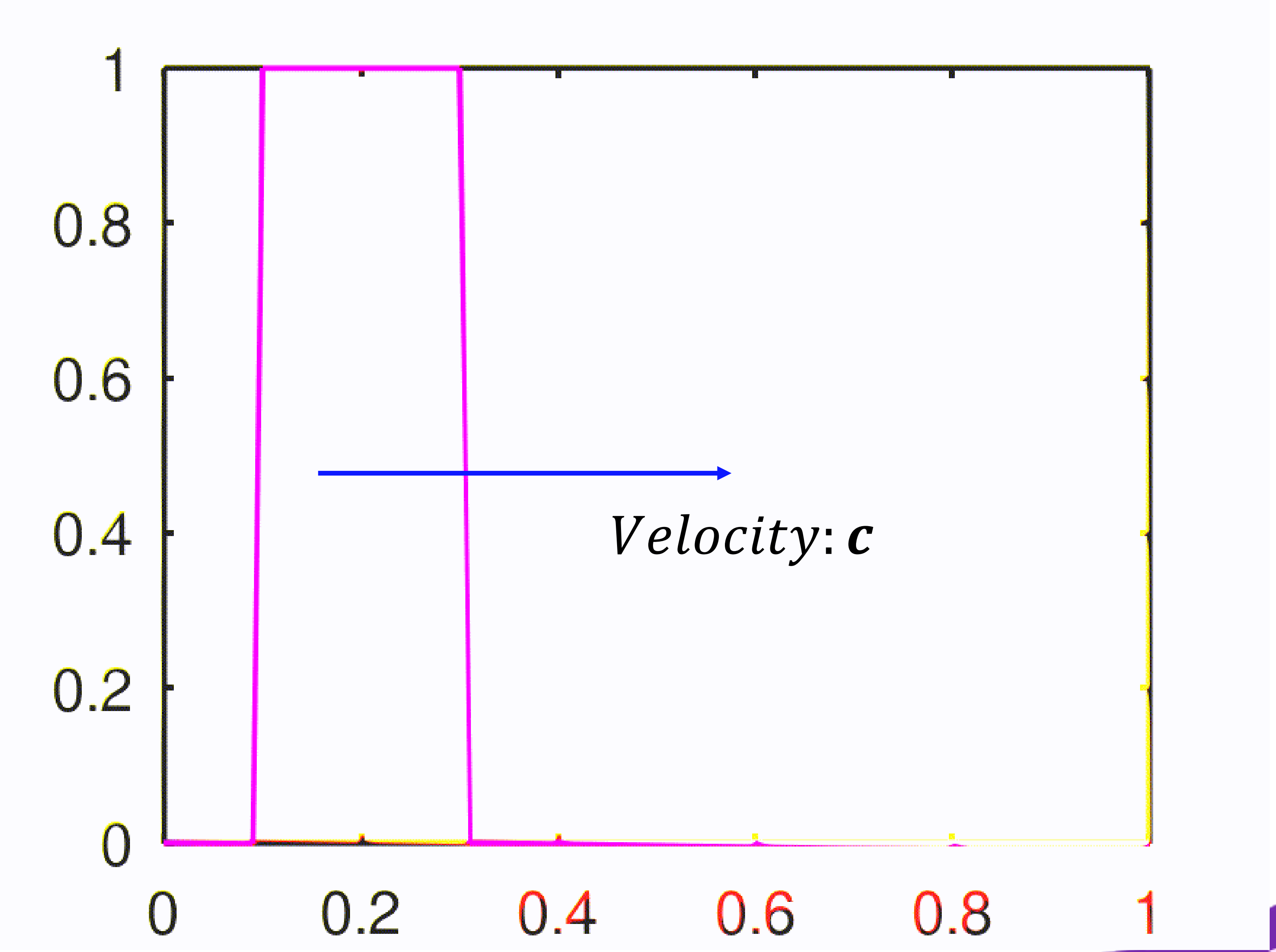
Convection Equation

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
```



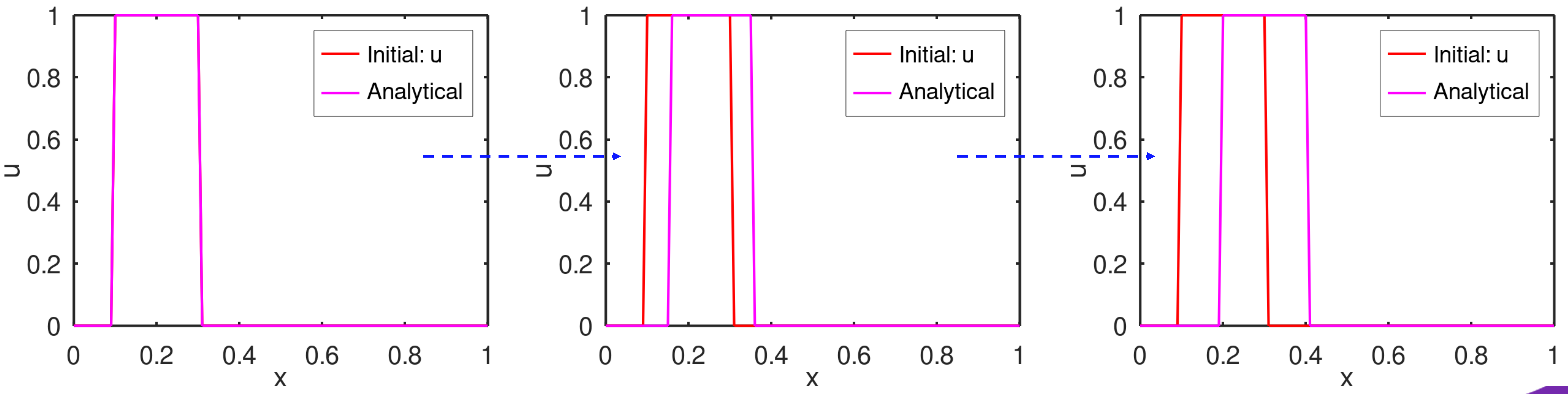


Convection Equation

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

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
```



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Convection Equation

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

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

x_{i-1} x_i x_{i+1} x_{i+2}

x_{i-1} x_i x_{i+1} x_{i+2}

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

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

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

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

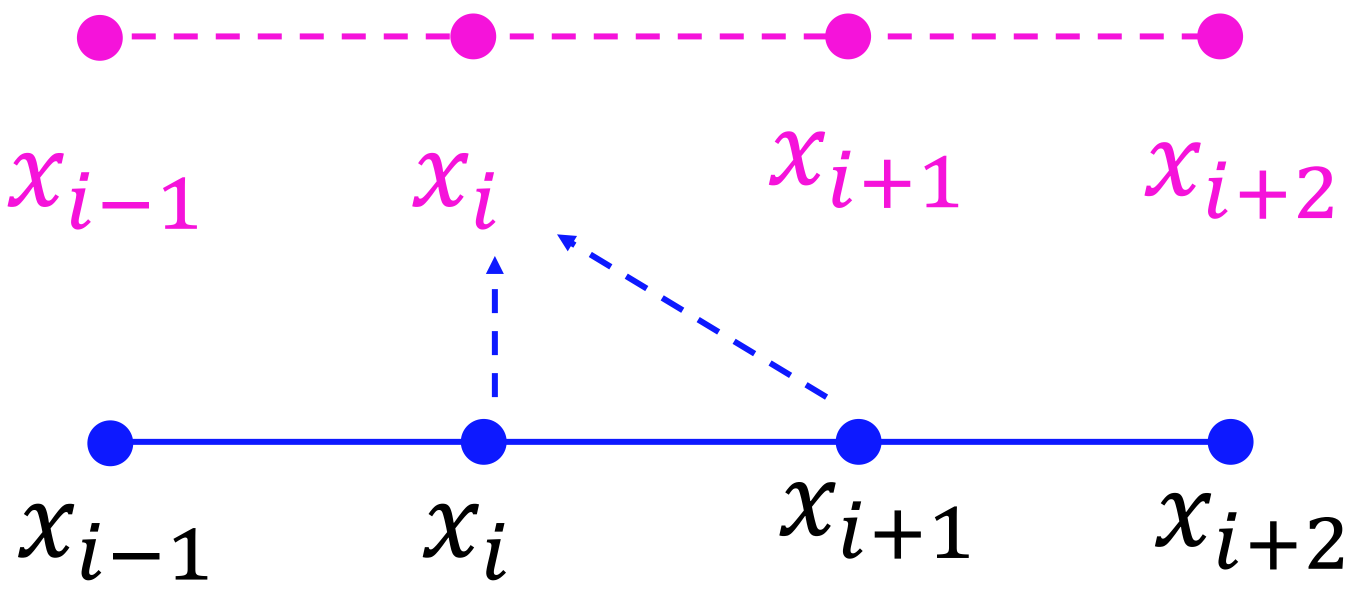
(Explicit) First order - Forward Euler

(only one unknown (n+1) with other knowns at n^th node)
→ conditionally stable

Convection Equation

Time level: $n+1$

Time level: n



Information from right to left end

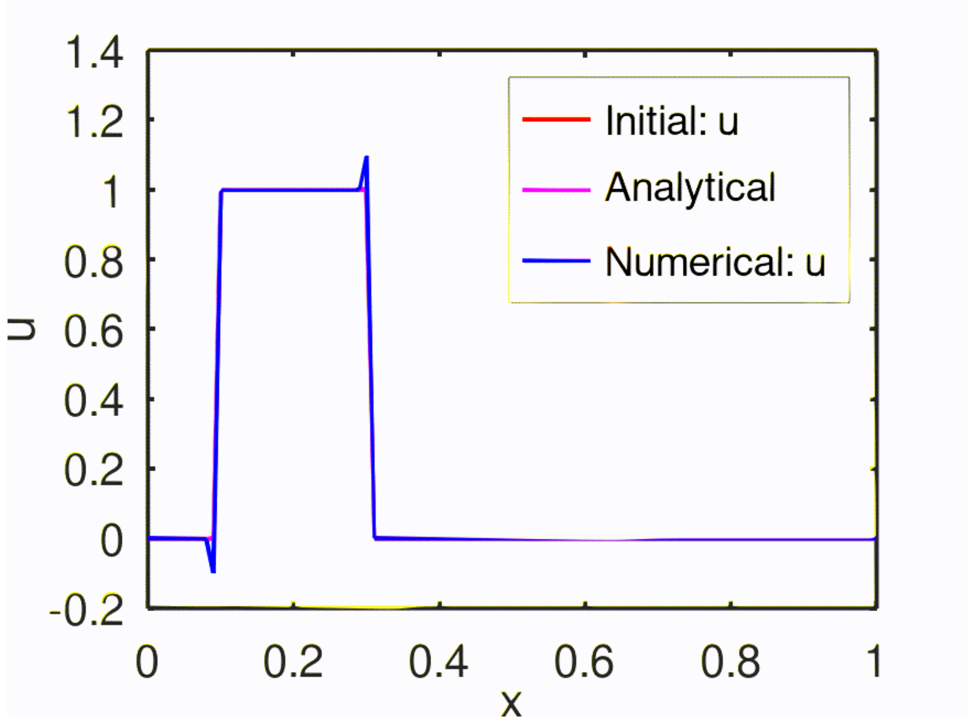
$$u_i^{n+1} = u_i^n - c\Delta t \boxed{\left(\frac{\partial u}{\partial x}\right)_i^n}$$

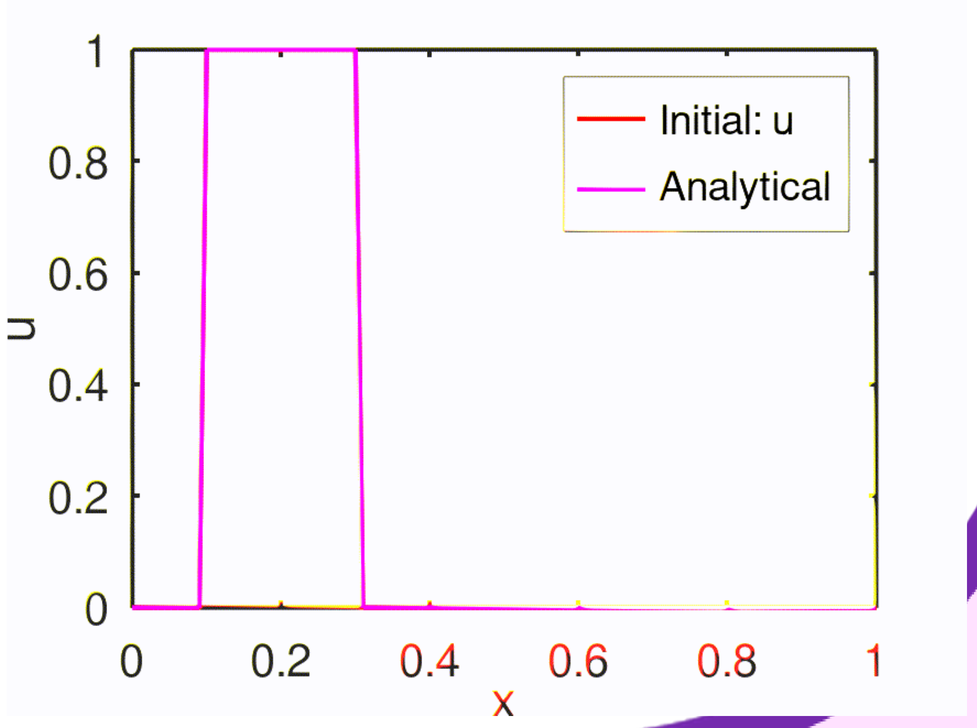
$$\left(\frac{\partial u}{\partial x}\right)_i^n \approx \frac{u_{i+1}^n - u_i^n}{\Delta x_i}$$

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

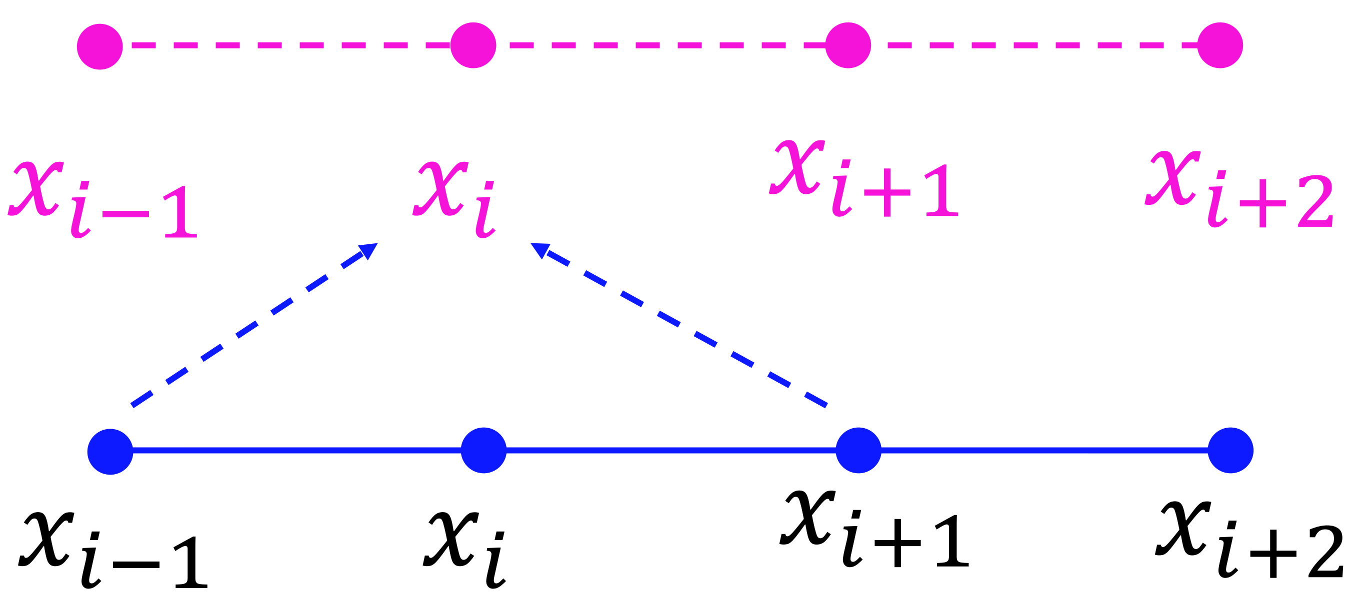




Convection Equation

Time level: $n+1$

Time level: n



Information from left and right ends

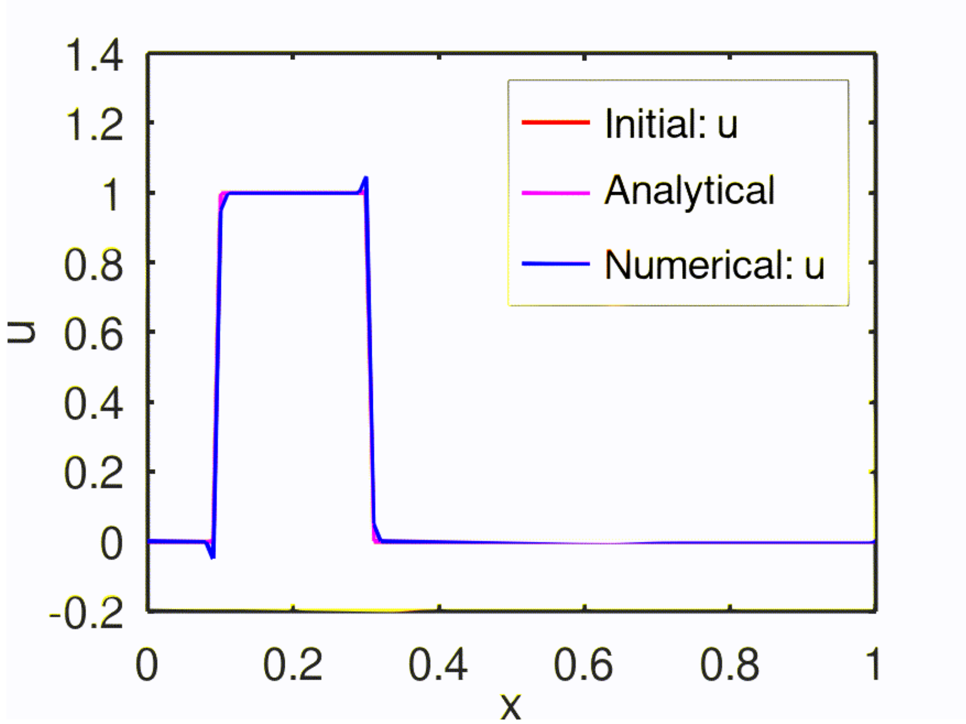
$$u_i^{n+1} = u_i^n - c\Delta t \boxed{\left(\frac{\partial u}{\partial x}\right)_i^n}$$

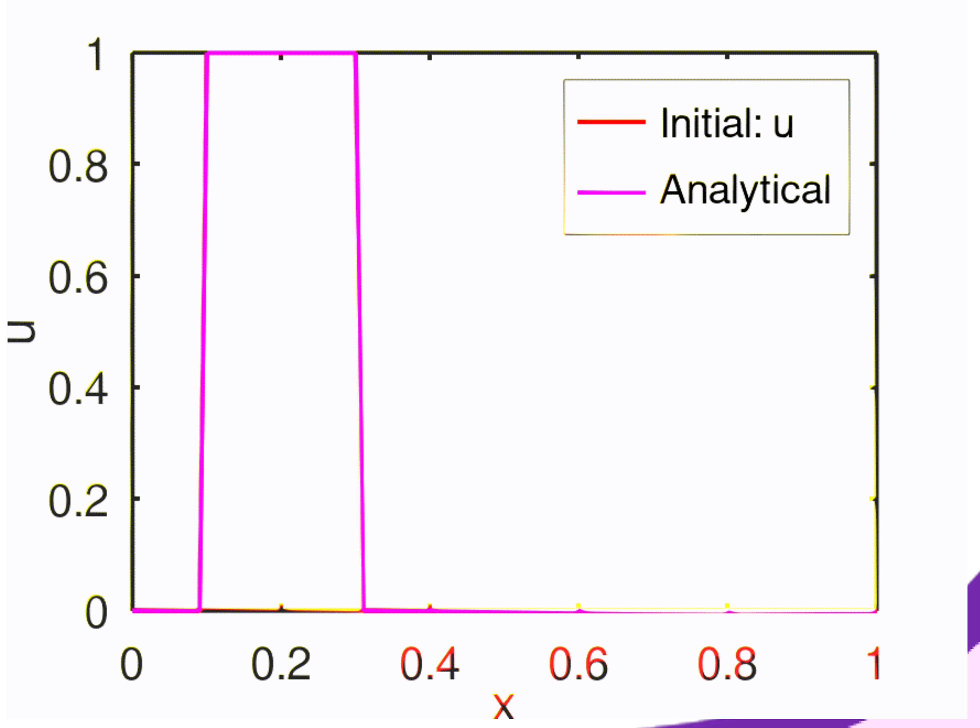
$$\left(\frac{\partial u}{\partial x}\right)_i^n \approx \frac{u_{i+1}^n - u_i^n}{\Delta x_i}$$

Simple forward difference scheme

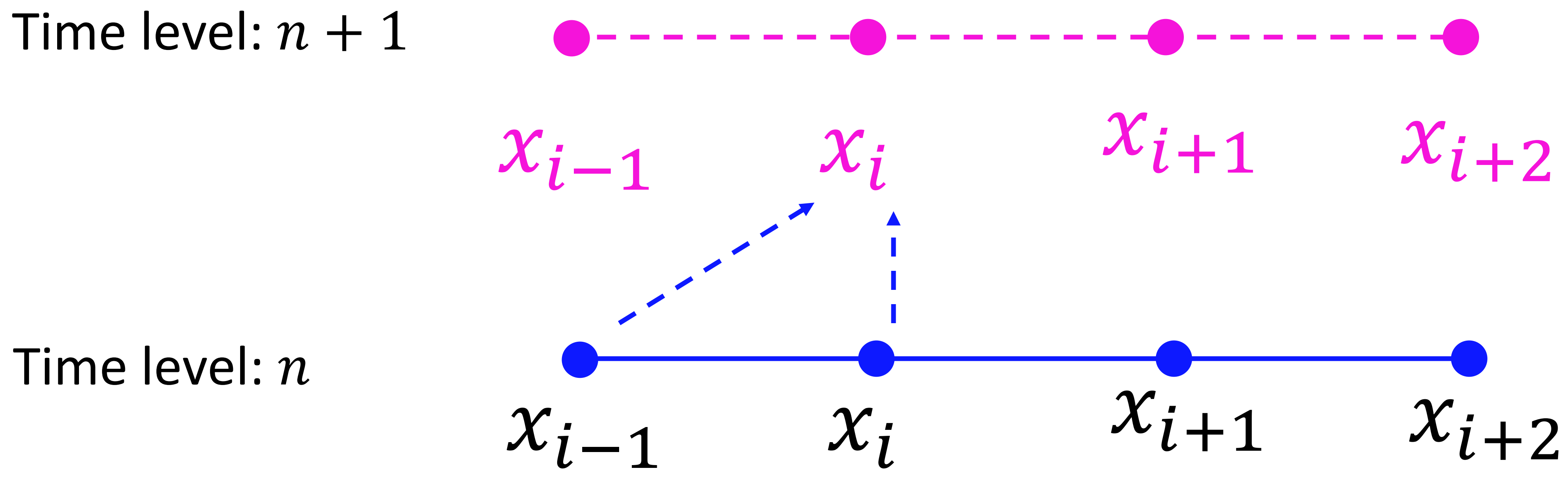
$$\left(\frac{\partial u}{\partial x}\right)_i^n \approx \frac{u_{i+1}^n - u_{i-1}^n}{2\Delta x_i}$$

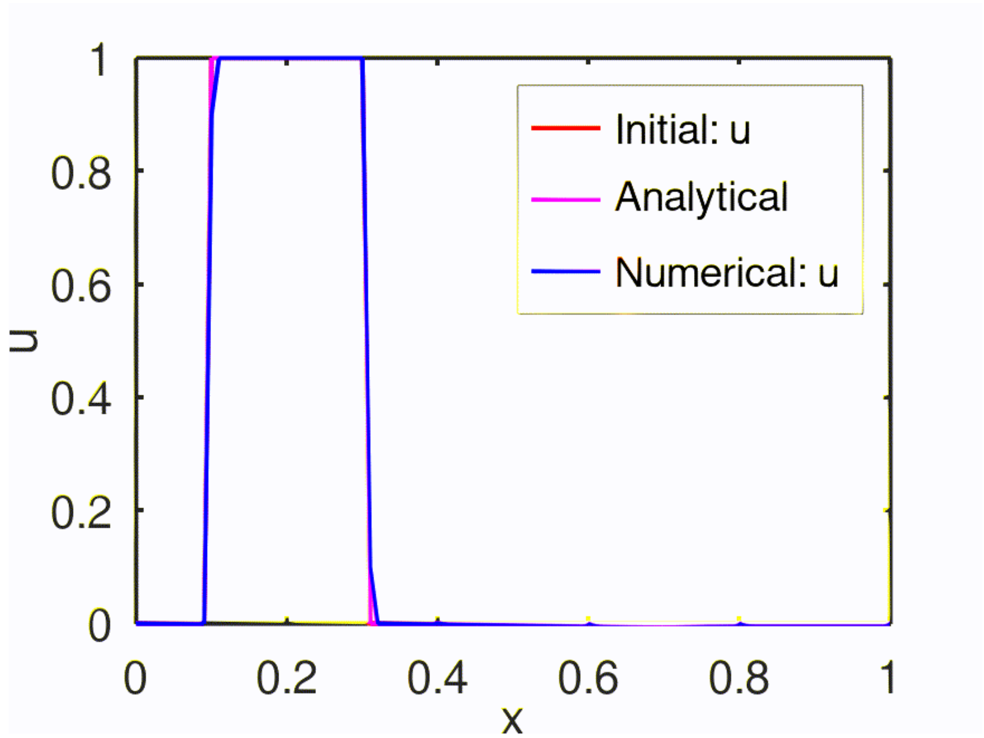
Central difference

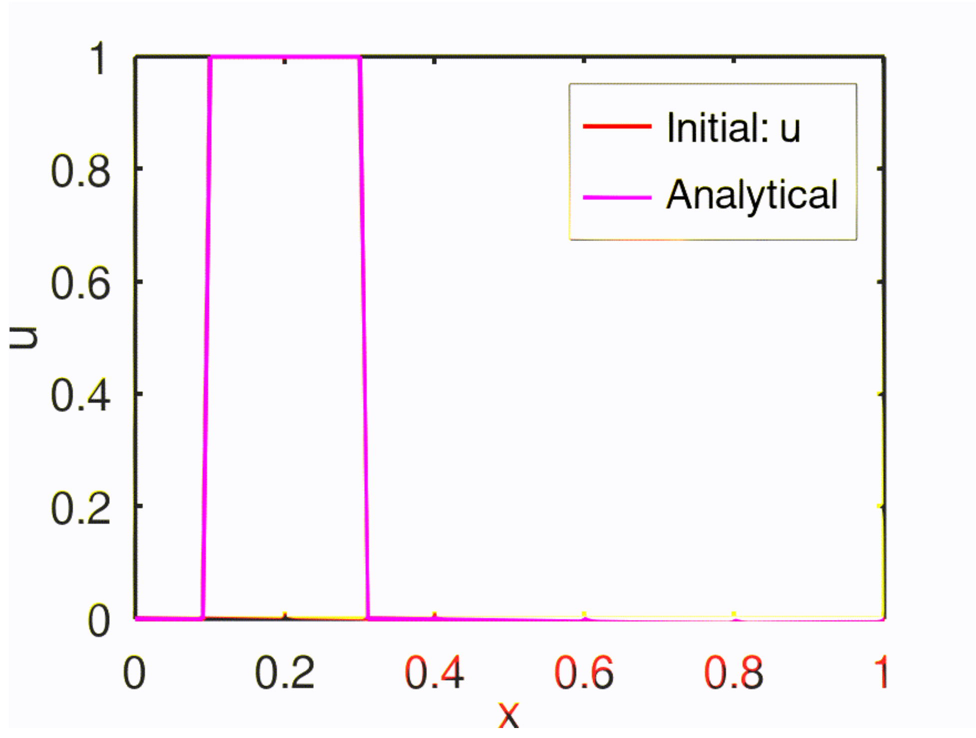




Convection Equation







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 $\quad CFL: \dfrac{c\Delta t}{\Delta x}$

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 using OpenFOAM #10

kummi0402 started this conversation in General

kummi0402 6 minutes ago Maintainer

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↑ 1

THANK YOU