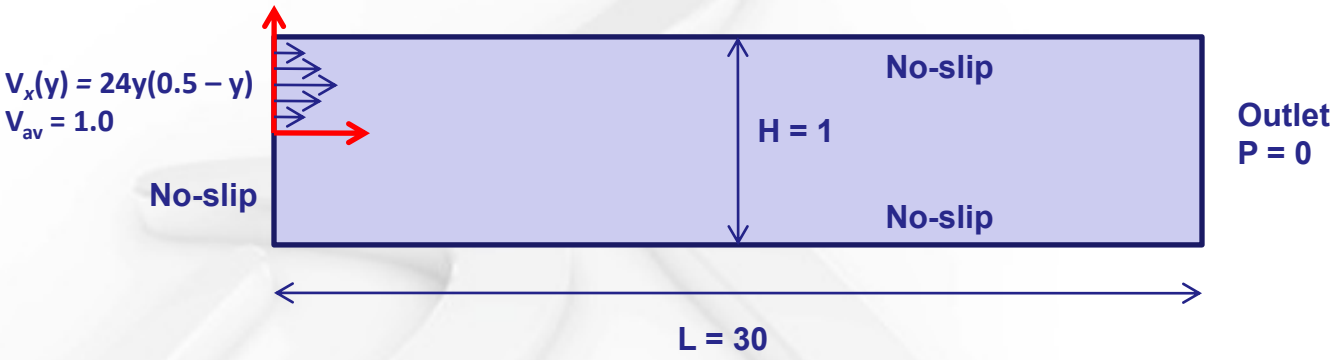
6. Flow Over a Backward Facing Step

Flow Over a Backward Facing Step

- **Overview**
  - This example simulates the laminar flow over a backward facing step at a Reynolds number of 800 based on channel height. The results are compared with numerical as well as experimental results available in literature.
- **Problem description**
  - The computational domain for the flow calculations consists of an rectangular region ($0 < x < 30$; $-0.5 < y < 0.5$). The flow enters the solution domain from $0 < y < 0.5$ while $-0.5 < y < 0.0$ represents the step. A parabolic velocity profile is specified at the inlet.



$$\mathrm{Re} = \frac{\rho V_{av} H}{\mu}$$

Flow Over a Backward Facing Step

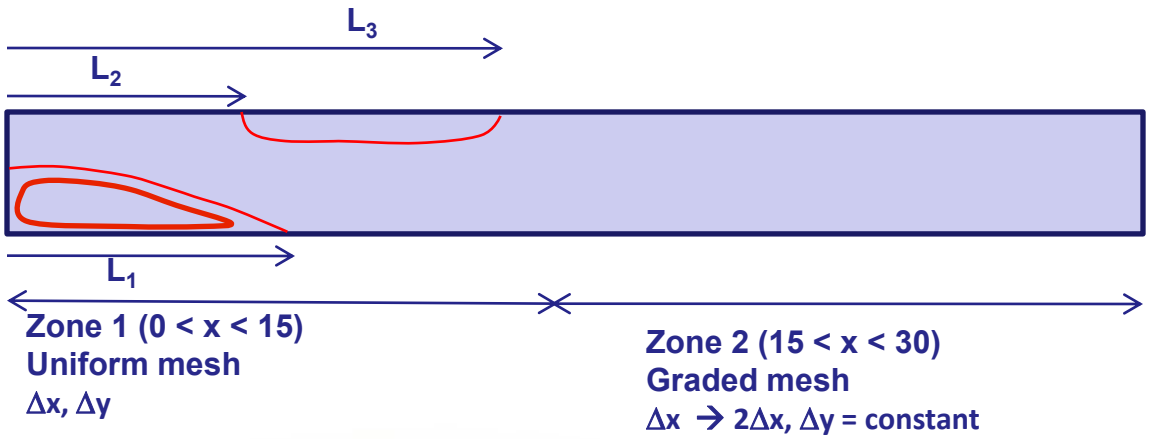
- **Features**
  - Steady laminar flow
- **Fluid Properties**
  - Density = 1 unit
  - Viscosity = 0.00125 units (the viscosity is chosen so as to set the flow Reynolds number to 800)
- **Boundary conditions**
  - Set through thickness velocity components to zero
  - No-slip velocity boundary condition at top and bottom walls
    - $V_x = 0, V_y = 0$
  - Inlet velocity: Parabolic velocity profile - $V_x = f(y)$
    - $V_y = 0$
  - Outlet: P = 0
  - No-slip velocity boundary condition at the step boundary
    - $V_x = 0, V_y = 0$

Flow Over a Backward Facing Step

- **References**
  - "A test problem for outflow boundary conditions – Flow over a backward-facing step"
    D. K. Gartling, International Journal for Numerical Methods in Fluids
    Vol 11, 953-967, (1990)

Flow Over a Backward Facing Step

Results



	Mesh (Across the channel x along the channel length)	L_1 Length from the step face to the lower re-attachment point	L_2 Length from the step face to upper separation point	L_3 Length of the upper separation bubble
Gartling (1990)	40x800	6.1	4.85	10.48
Abaqus/CFD	Fine 80x1200x1 (Zone 1) 80x832x1 (Zone 2)	5.9919	4.9113	10.334
Abaqus/CFD	Medium 40x600x1 (Zone 1) 40x416x1 (Zone 2)	5.7471	4.8379	10.101
Abaqus/CFD	Coarse 20x300x1 (Zone 1) 20x208x1 (Zone 2)	4.5018	3.9659	8.7748

- Elements used by Gartling (1990) were biquadratic in velocity and linear discontinuous pressure elements. In contrast, the fluid elements in Abaqus/CFD use linear discontinuous in velocity and linear continuous in pressure.

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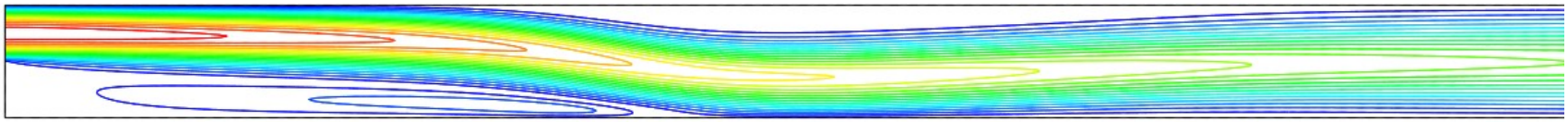
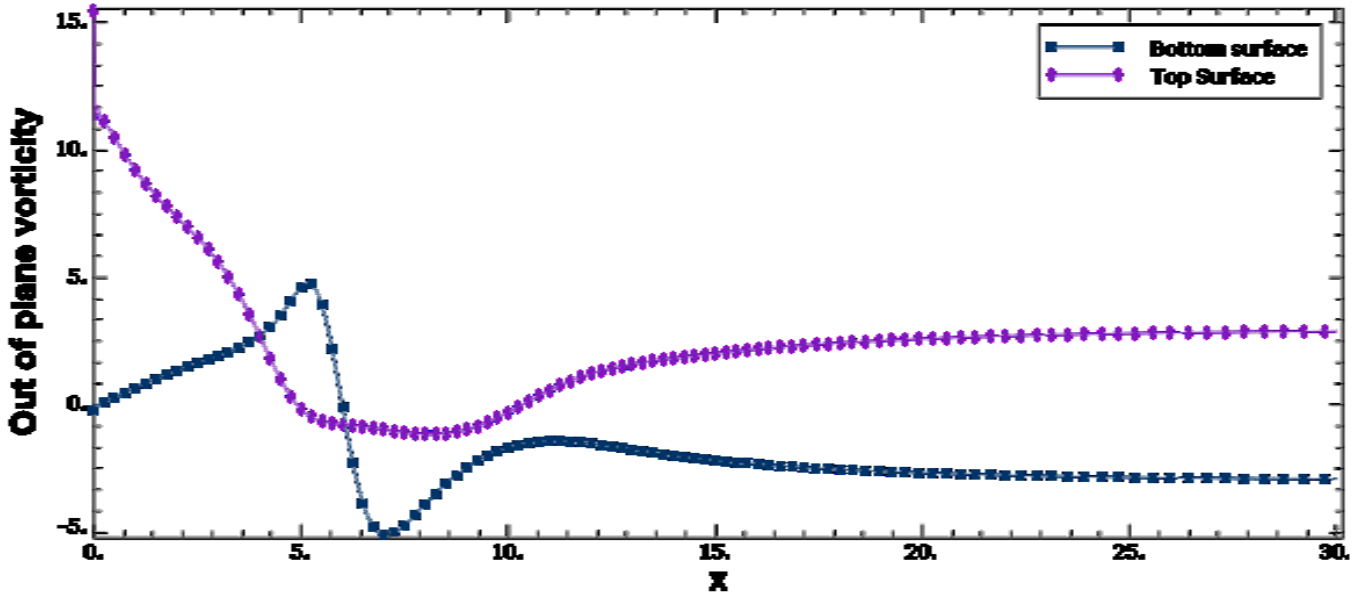
Results

Pressure line plot (0 < x < 30)



Velocity line plot (0 < x < 15)



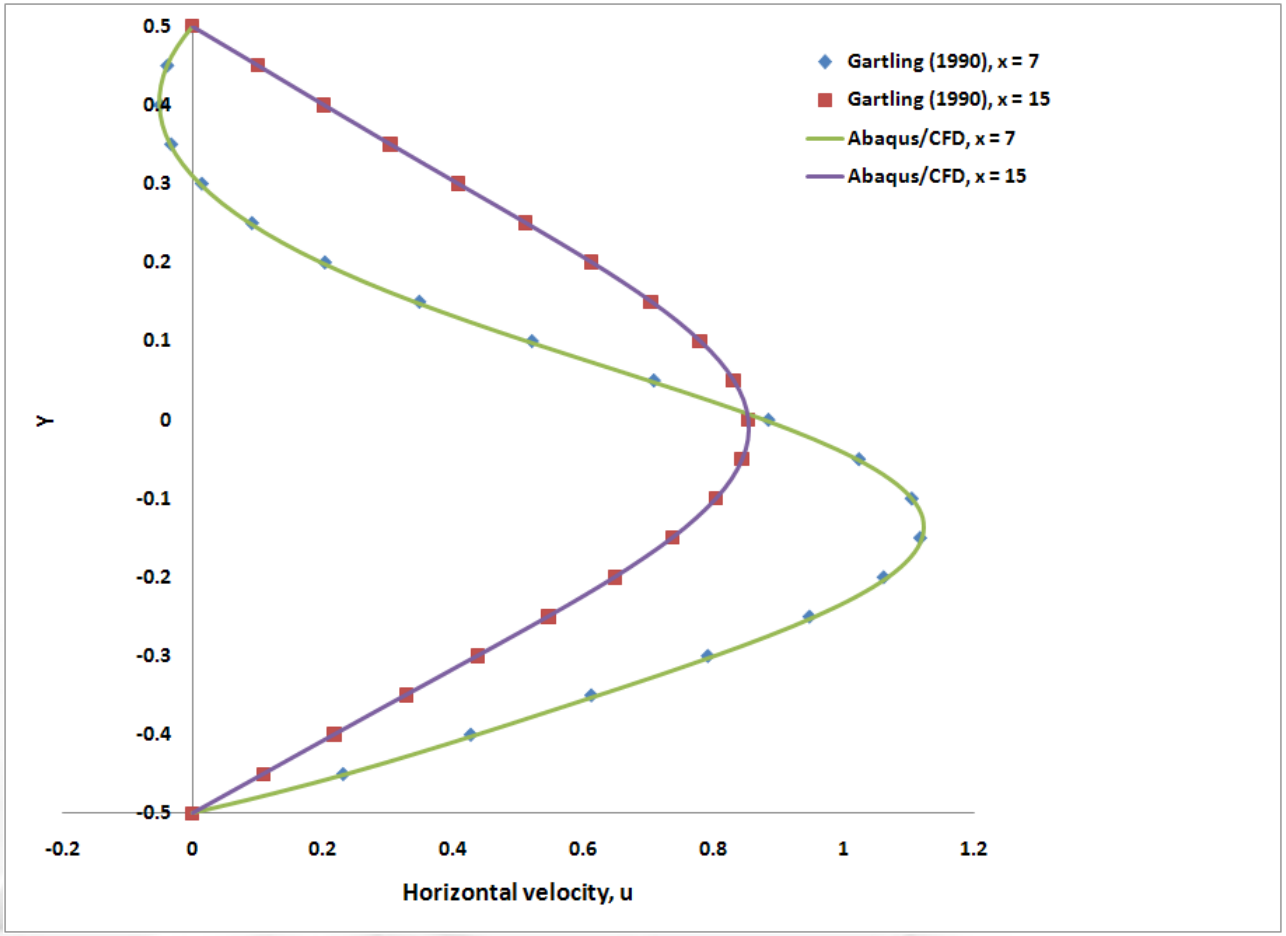
Out of plane vorticity (0 < x < 30)

SIMULIA

Flow Over Backward Facing Step

Results

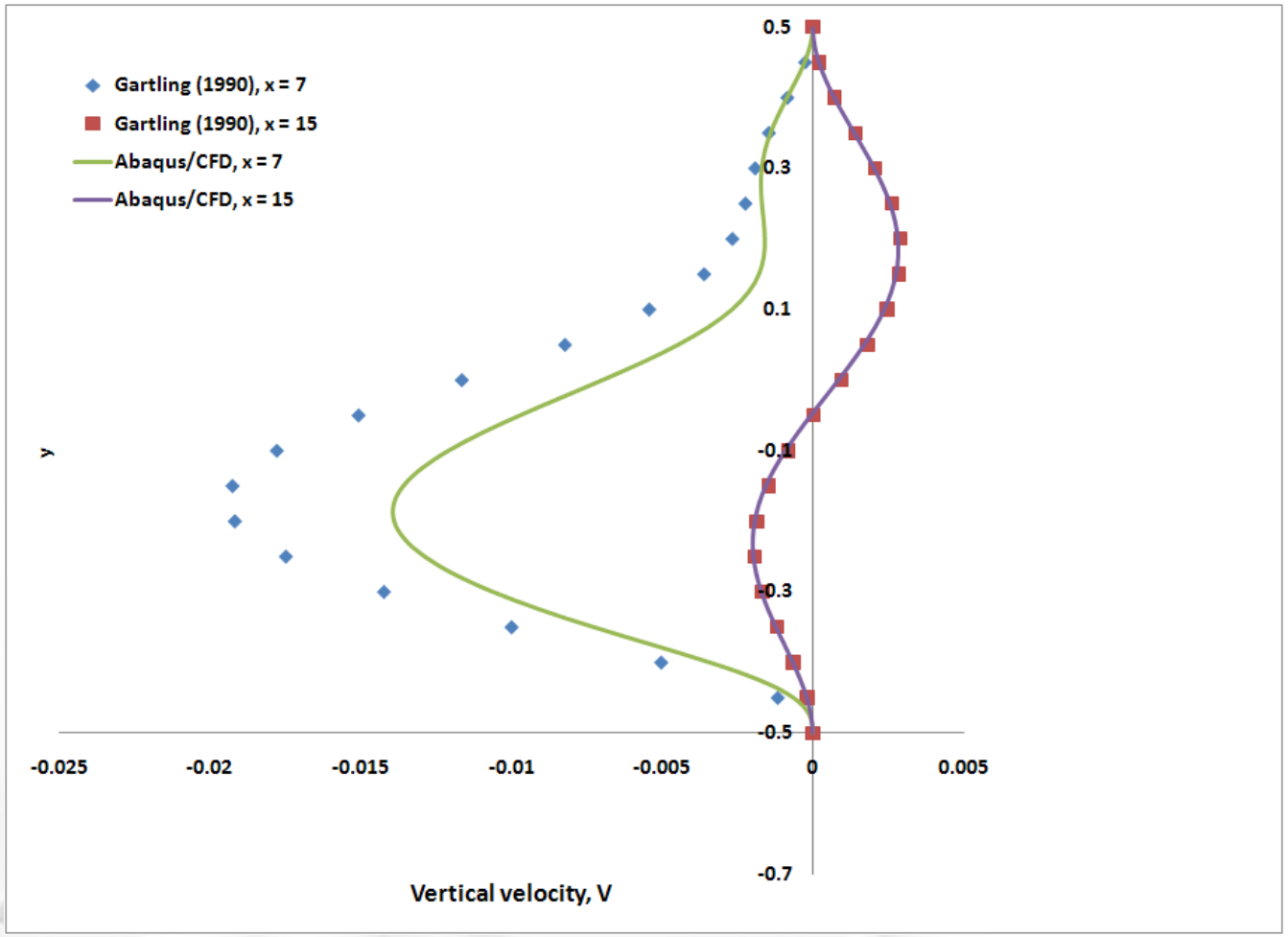
- **Horizontal velocity at x = 7 & x = 15**



Flow Over Backward Facing Step

Results

- **Vertical velocity at x = 7 & x = 15**



SIMULIA

Flow Over Backward Facing Step

- **Files**
  - ex6_backwardfacingstep.py
    - ex6_backwardfacingstep_coarse.inp
    - ex6_backwardfacingstep_medium.inp
    - ex6_backwardfacingstep_fine.inp
  - coarse_parabolic_inlet_velocity.inp
  - medium_parabolic_inlet_velocity.inp
  - fine_parabolic_inlet_velocity.inp

- **Note**
  - *The models require a parabolic velocity profile at the inlet. This needs to be manually included as boundary condition in the generated input file.*
  - *The parabolic velocity profile required is provided in files coarse_parabolic_inlet_velocity.inp, medium_parabolic_inlet_velocity.inp and fine_parabolic_inlet_velocity.inp for coarse, medium and fine meshes, respectively.*