1 Presentation of the test case

this study will be based on laminar flow around a step laid in a flat channel. The fluid is subjected to a sudden widening that causes an inverse pressure gradient, where the flow separates into several zones, among which a recirculation zone is formed, noted x_r, where the flow closes to return to the step. The Reynolds number denoted Re for this flow is calculated from the channel height S, the average flow velocity U$_{ave}$ and the kinematic viscosity ν, and is defined by:

$$\mathrm{R}e = \frac{\mathrm{SU}_{ave}}{\nu}$$

and as $\nu = \frac{\mu}{\rho}$ so :

$$\mathrm{R}e = \frac{\mathrm{S\rho U}_{ave}}{\mu}$$

When the flow has low Reynolds number values it is said to be stationary, while flows with higher Reynolds number values become unsteady and the average length of the recirculation zone decreases until reaching a constant saturation value, in this project we will only be interested in the unsteady case for two different Rynolds number values Re = 389 and Re = 1095.

The computational domain Ω is a channel with a descending step as shown in the figure below.
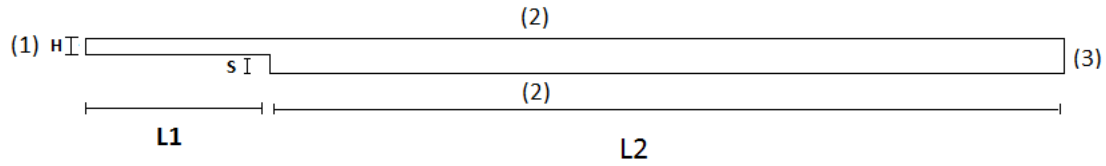

Figure 1: Calculation area.

The Data provided on the whole Ω domain allows us to have conditions at the specified limits, the tables below summarize these data.

Name	Description	Nominal Value	Units
L1	Length of the upstream section	2e-1	m
L2	Length of the downstream section	5e-2	m
S	Step height	4.9e-3	m
H	Inlet channel height	5.2e-3	m
U$_{int}$	Initial velocity	-	m/s
U$_{ave}$	Average velocity	-	m/s

Table 1: Geometric data

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Name	Description	Nominal Value	Units
ρ	density	1.23	Kg/m^3
μ	dynamic viscosity	1.79e-5	$Pa.s$
ν	kinematic viscosity	1.4553e-5	m^2/s

Table 2: Physical data

In this study 3 boundary conditions are imposed:

1. Inlet condition : On boundary (1) a Poiseuille profile is placed as an entry condition, it is defined by:

$$u = U_{int} = 6U_{ave}(\frac{y_1}{H})(1 - \frac{y_1}{H}) \tag{1}$$

such as:

$$y1 = y - S$$

and U_{ave} are derived from the selected Reynolds number as:

$$U_{ave} = \frac{\nu Re}{S} = \frac{\mu Re}{\rho S}$$

The profile of Poiseuille at the entrance is represented by the graphs below:
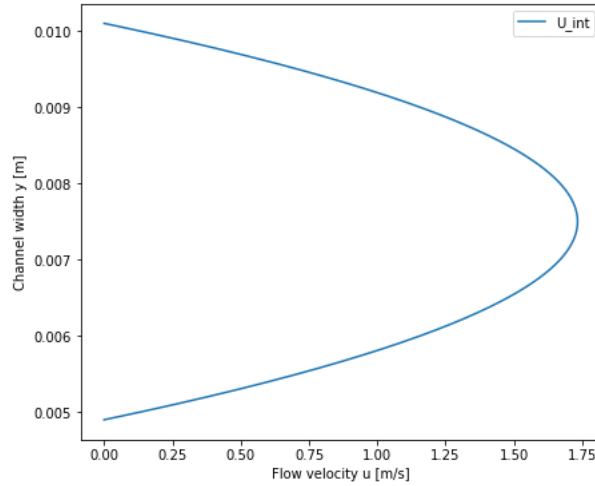
(a) For $Re = 389$:

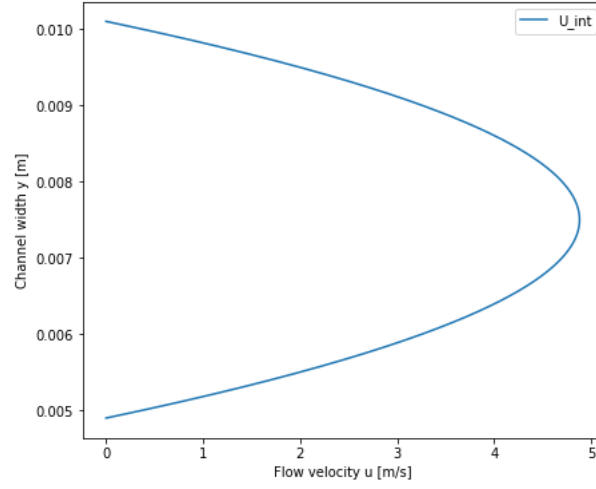Figure 2: Profile of Poiseuille at the entrance for Re=389

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(b) For Re = 1095:

Figure 3: Profile of Poiseuille at the entrance for Re=1095

2. Wall condition : On the limits (2), i.e. on the upper and lower wall we have

$$u = 0 \qquad (2)$$

3. Outlet condition : On boundary (3) the exit boundary condition is free, which means that no constraint is imposed on the exit boundary.

To study the laminar flow around a backward Facing Step we have devised the geometry [Figure 1] in conformal blocks as the figure below illustrates :
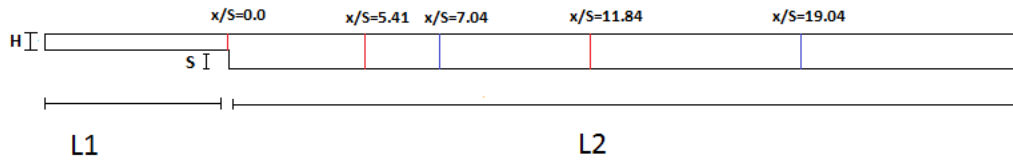

Figure 4: Splitting the Ω domain into conformal blocks

After cutting our domain, we move on to meshing to generate fully structured uniform triangular cells, [Figure 5] shows a part of the generated mesh
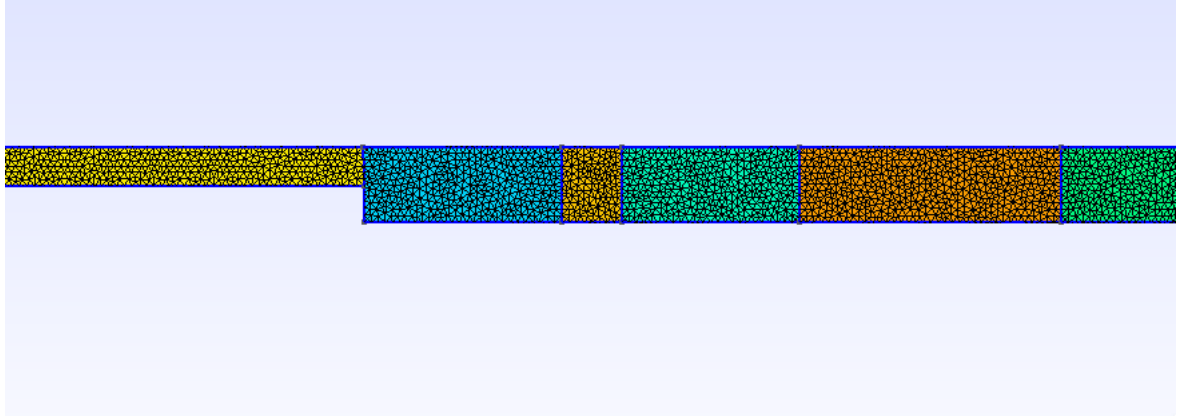

Figure 5: Generated mesh

The study will be based on the flow velocity profile for $Re = 389$ and $Re = 1095$ on different vertical x_r/S lines shown in the [figure 4].

2   Results

For the readability of the results, we have separated the calculations at Re= 389 and those at Re=1095.

2.1   Recirculation at Re=389

2.2   Recirculation at Re=1095