Simulation of Recirculating Flows

Recirculating flows are often encountered within industrial equipment. Examples are orifices, sudden expansions, flow in channels with baffles, flows in sloping wall combustors, etc. In this project, the five geometries we will collectively study are:

a) Flow over a planar sudden expansion
b) Flow in an axisymmetric sudden expansion
c) Flow in a channel with an orifice
d) Flow in a planar channel with a baffle
e) Separated flow in a diffuser of different half-angles

You should select two geometries to model from among the foregoing options. The Reynolds number will be kept small (near 100) to ensure a smaller streamwise length as well as laminarity. For each problem, the effect of Reynolds number and grid resolution will be studied. Select three values for *either* Reynolds number (Re $\leq$ 100) at a fixed grid resolution of 0.025 H *or* grid resolution (maximum areal size 0.1H, 0.05H, 0.025H) for a fixed Re = 100.

The Reynolds number may be calculated on the assumption that the channel is a square duct. The hydraulic diameter of a square duct is $D_H = 4A/P$, where A is the cross-sectional area and P is the perimeter. Show your calculation in your report.

You will document your simulations in a 10 page report (with figures) containing the sections:

a) Problem description (shape, grid resolution and mesh quality, etc.)
b) Details of the simulation (settings and capabilities of Fluent insofar as you can)
c) Numerical parameters (laminar flow, grid size, boundary velocity, initialization, etc.)
d) Computational times (iterations and CPU time to complete)
e) Observations of numerical behavior (residual convergence rate, mesh behavior, etc.)
f) Discussion of the flow physics (stream behavior, vortices, flow separation, etc.)

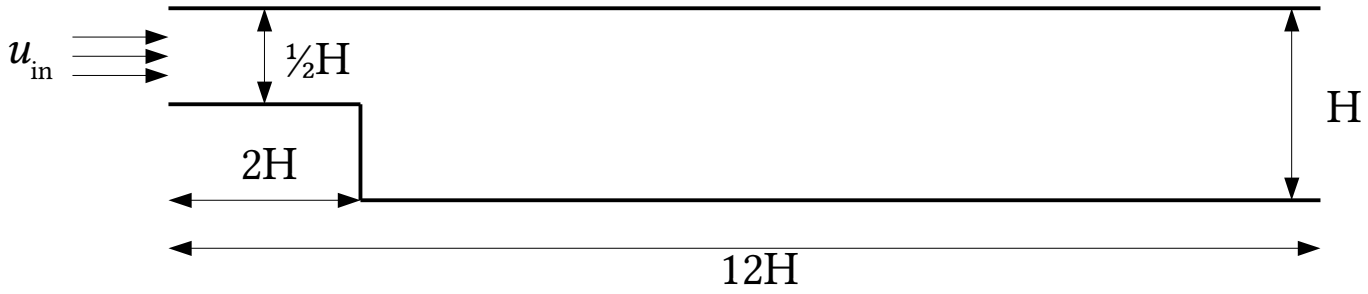
Include the following plots in your report, with data from each case your team will study:

a) Convergence of mass, momentum residuals
b) Streamlines
c) Line plots of pressures along the wall (on the side of the obstruction or expansion; thus the bottom wall in all of the following geometries)
d) Contours of pressure

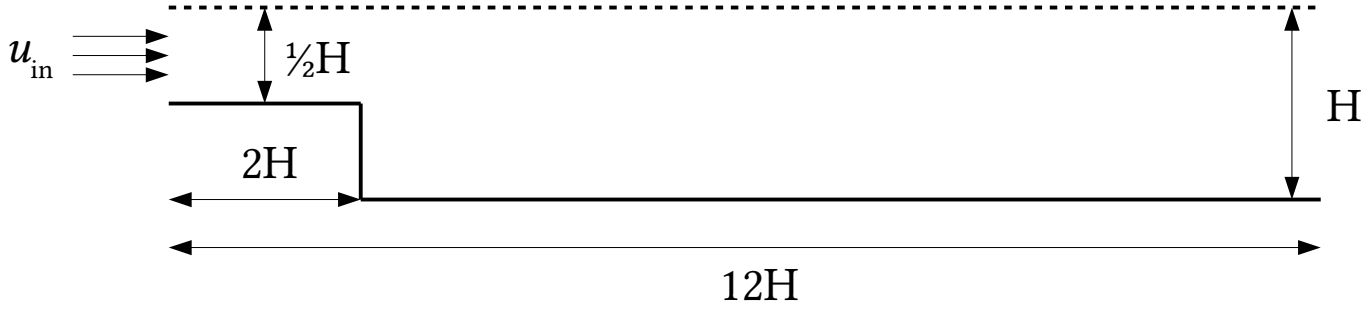
The report should be formatted with 1.5 line spacing, 1 inch margins on all sides, and set in 11 point serif font. All figures and tables (if any) should be numbered and have labels and captions. Saha (2008) exemplified how to document numerical simulations for this type of problem (although your report will not be as technical). Submit a hard copy on the due date at the beginning of class.

In addition, you should submit a streamline plot of your maximum resolution, maximum Reynold number simulation so that we can jointly review the results of this project in class.

Planar sudden expansion

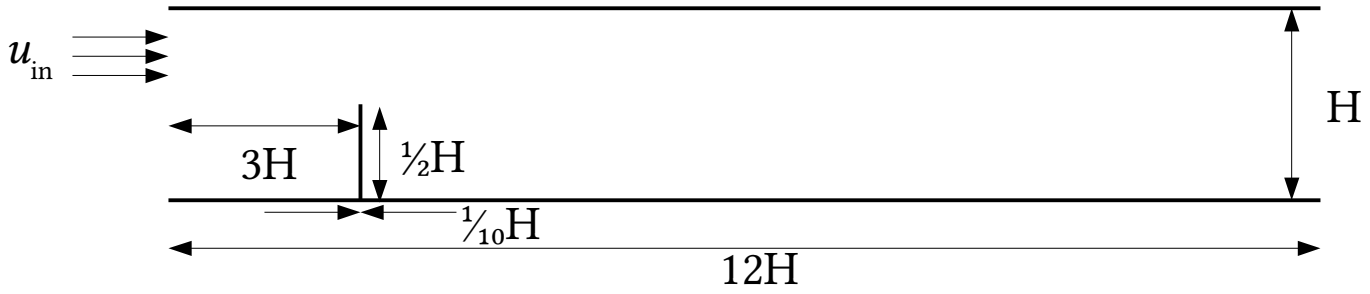


Axisymmetric sudden expansion

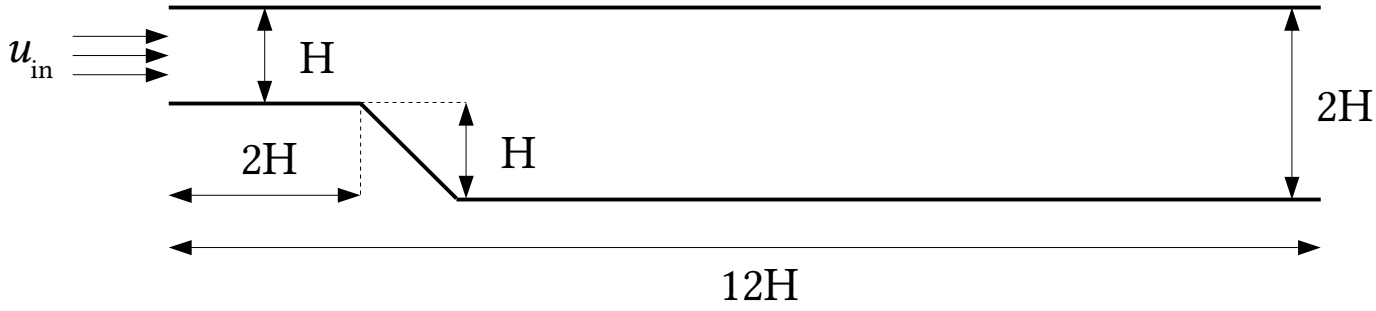


Orifice

Baffle



Diffuser at 45°



$\mathrm{Re} = \frac{\rho u_{in} D_H}{\mu}$ for all geometries