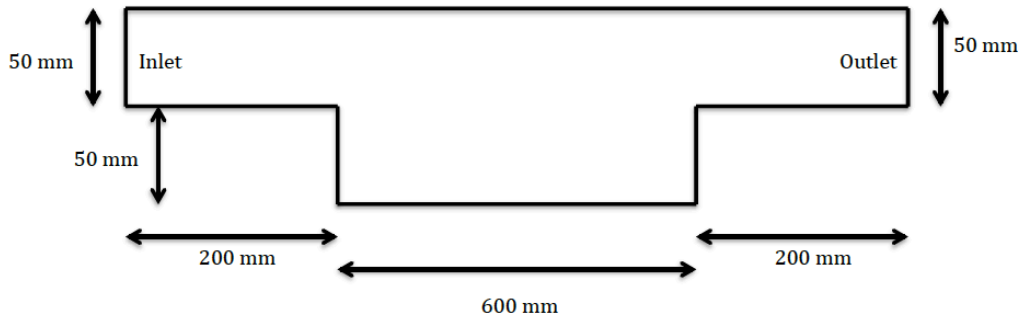


Figure 1: Geometry considered. Flow is entering through the Inlet and exits through the Outlet. All remaining boundaries are solid walls.

Mandatory exercise MEK4470/9470, Fall 2022

1 Implement a 1D solver using TVD

Consider Example 5.1 in Versteeg et al. Implement a solver using TVD for convection and show convergence in the L2-norm. Choose any or all of the TVD schemes from the Table on p170. As a suggestion, but not a requirement, try to implement a generic TVD solver where the scheme can be chosen from the command line.
What properties do TVD schemes possess?

An L2-norm can be defined for a real function $u(x)$ in a domain Ω as

$$|u| = \sqrt{\int_\Omega u^2 dx}$$

The integral can be computed in Python using, for example, the trapz method for trapezoidal integration. See also methods for integration in Scipy. In measuring the error norm, replace u by the vector of nodal errors (your solution in the nodes minus the exact solution in the nodes).

2 OpenFOAM assignment

Consider the geometry shown in Fig. 1. Air at 20 ^{o}C is entering through the Inlet at an average velocity of 10 m/s and exits through the Outlet. All other boundaries are solid walls with no-slip boundary conditions. The pressure is set to constant 0 on the Outlet.

1. Consider the pisoFoam solver. Explain how the PISO algorithm works with reference to the implementation in pisoFoam.

2. Use pisoFoam and solve this flow using an LES model in 2D. Give a complete description of this problems equations and all boundary conditions used. Report the mean velocity and pressure. Submit also a movie of the

instantaneous flow field. Justify the choice of numerical scheme for convection. Comment on grid sensitivity. Is the solution mesh independent.

3. Use pimpleFoam or simpleFoam and solve this flow using two different two-equation RANS models of your own choice. Give a complete description of the model equations including all boundary conditions used. Report the mean velocity and the mean kinetic energy. Justify the choice of numerical scheme for convection. Comment on grid sensitivity. Is the solution mesh independent.

4. Why is pimpleFoam more suitable for RANS than for LES?

5. Compare the results from LES and RANS. Give in particular the position of the recirculation bubble.

6. Why is LES usually not used as a 2D model?