ME608 - 2D SIMPLE Solver for Laminar Flow Over a Square Cylinder - Spring 2010

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Outline

- Geometry, Mesh, and BCs
- Solver details
- Results
- Validation
- Summary

Details of Flow Domain

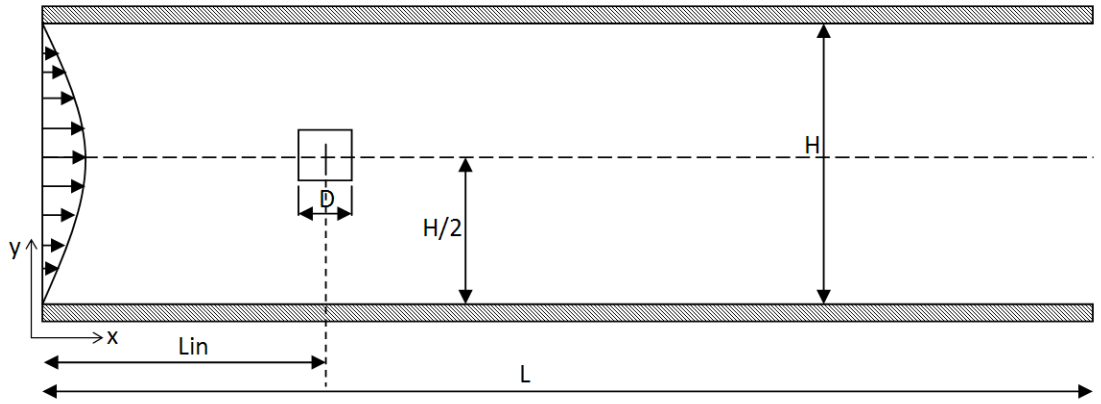


Figure: Geometry of the flow over 2D square cylinder

- Side of the square D = 1 is the length scale.
- H = 8D; L = 50D; Lin = 12.5D;
- Channel is meshed with 500 x 80 control volumes with 10 x 10 across the square cylinder.
- Boundary Conditions:
  1. Inlet: Parabolic velocity inlet
  2. Outlet: Upwinded mass flow outlet
  3. Walls: No slip wall

Details of Solver

- SIMPLE solver on staggered mesh
- Gauss-Seidel for momentum equations
- LBL-TDMA for pressure correction equation

Discrete u and v momentum equations

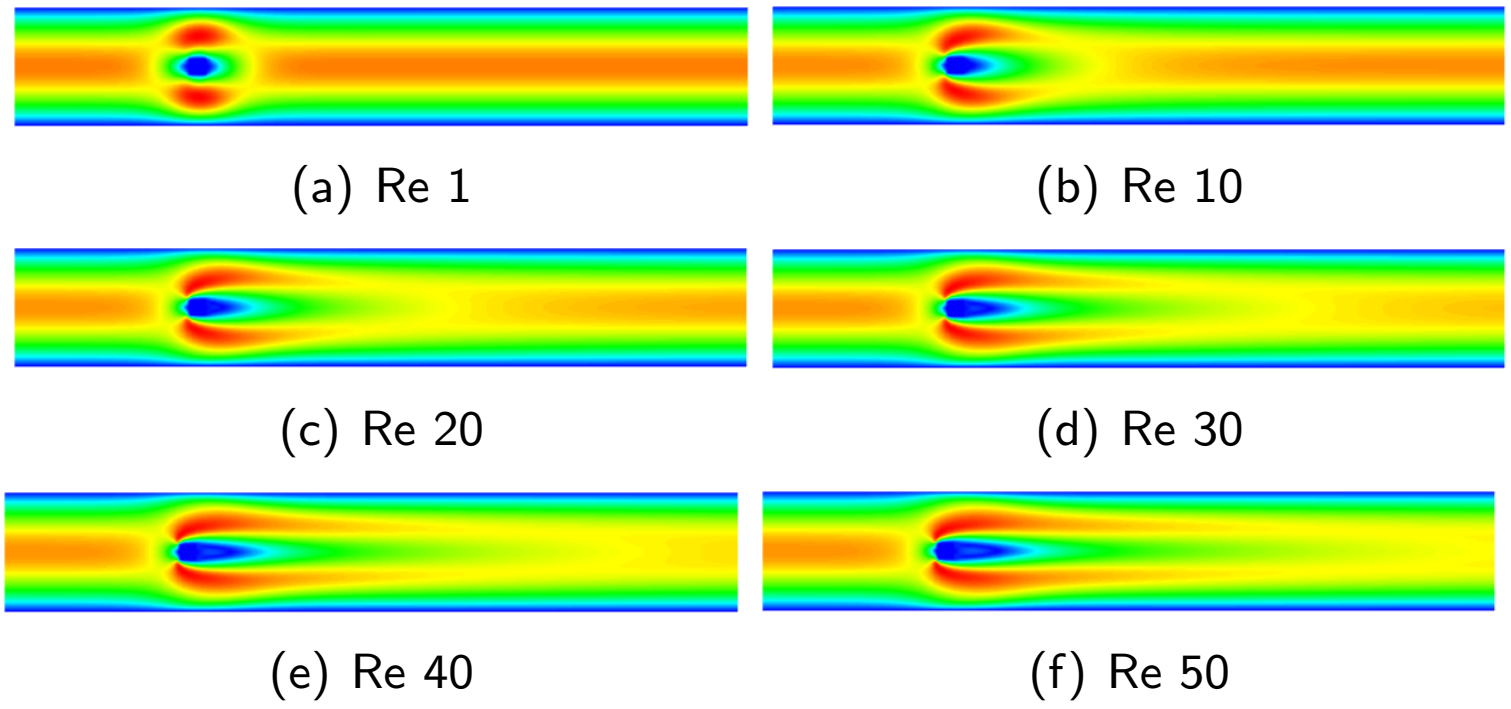
$$a_e^u u_e = \sum_{nb} a_{nb}^u u_{nb} + b_e^u + \Delta y(P_P - P_E) \tag{1}$$

$$a_n^v v_n = \sum_{nb} a_{nb}^v v_{nb} + b_n^v + \Delta x(P_P - P_N) \tag{2}$$

Pressure correction equation

$$a_P p_P^{'} = \sum_{nb} a_{nb} p_{nb}^{'} + (F_w^* - F_e^* + F_s^* - F_n^*) \tag{3}$$

Results - Velocity



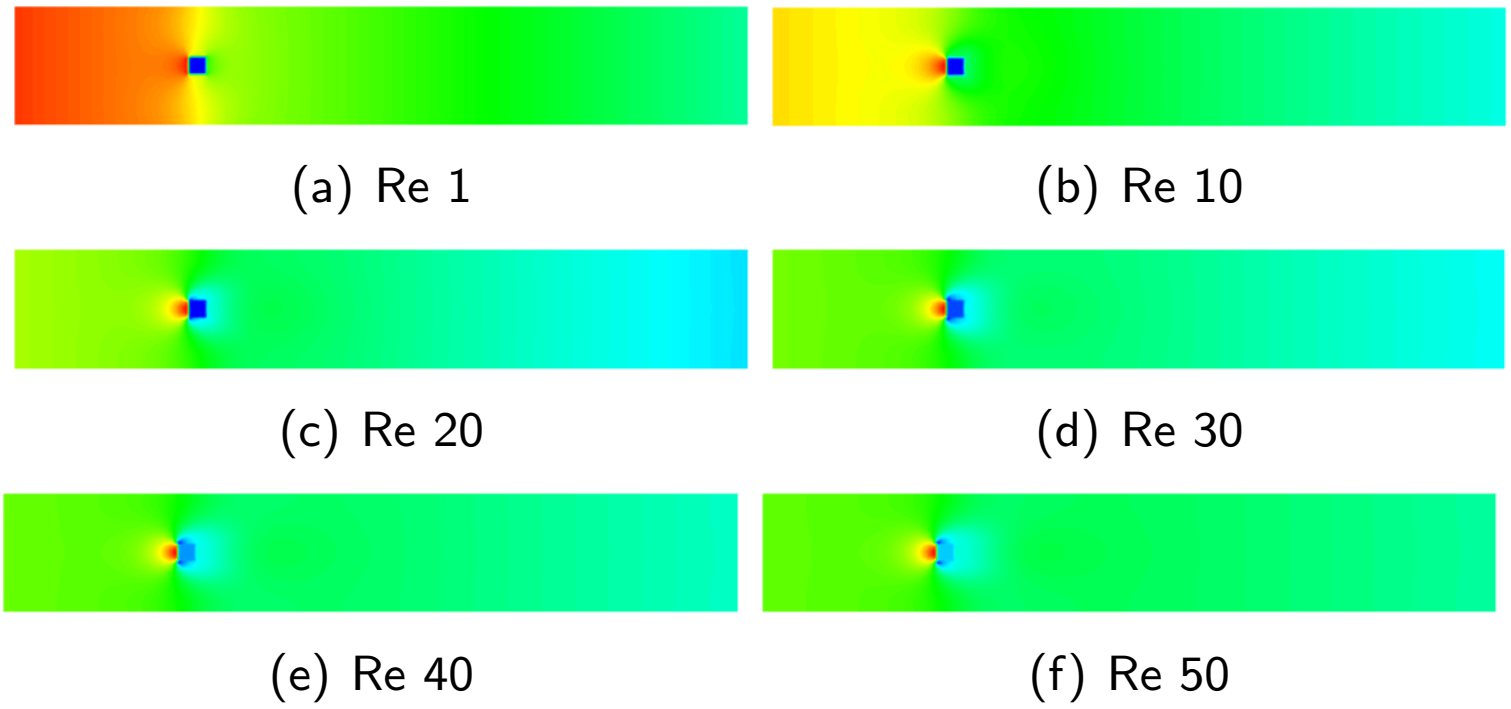
(a) Re 1 (b) Re 10

(c) Re 20 (d) Re 30

(e) Re 40 (f) Re 50

Figure: Velocity Profiles

Results - Pressure



(a) Re 1 (b) Re 10

(c) Re 20 (d) Re 30

(e) Re 40 (f) Re 50

Figure: Pressure Profiles

Results - Vorticity

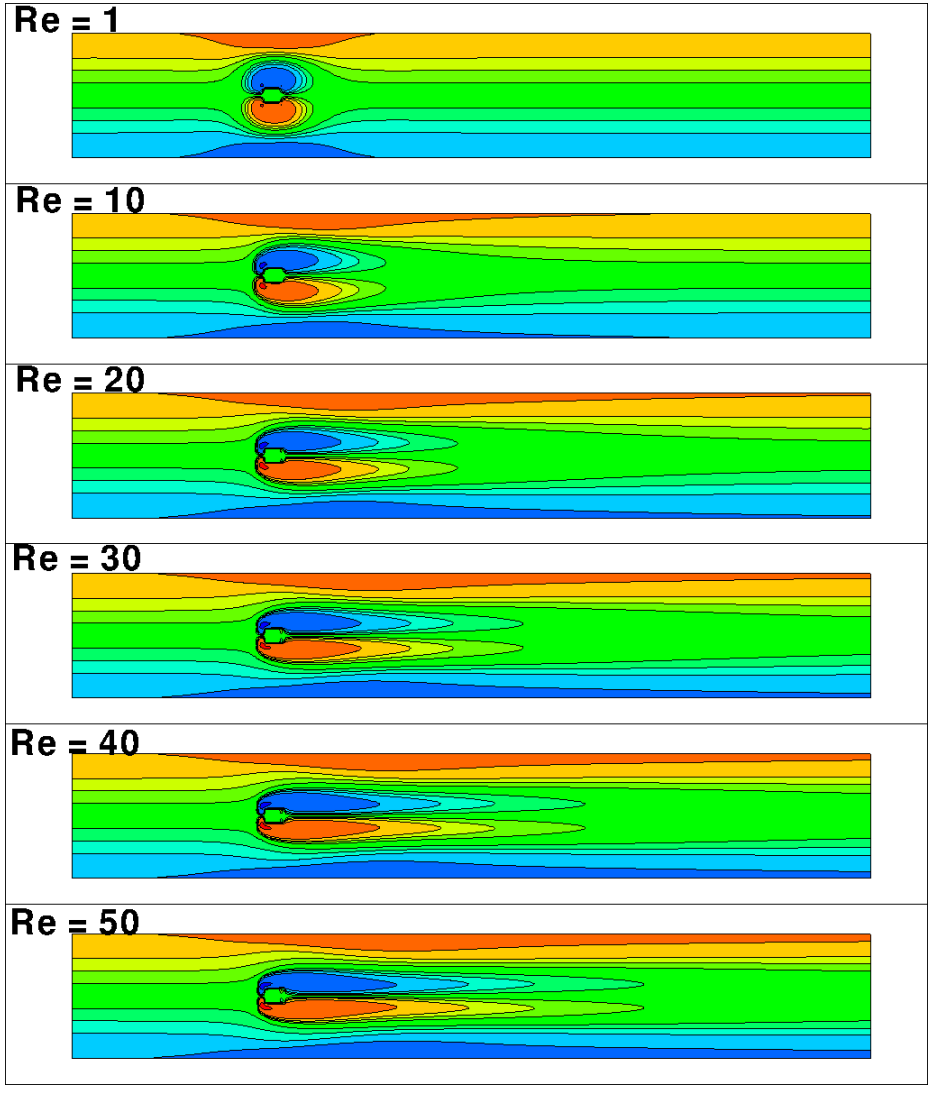
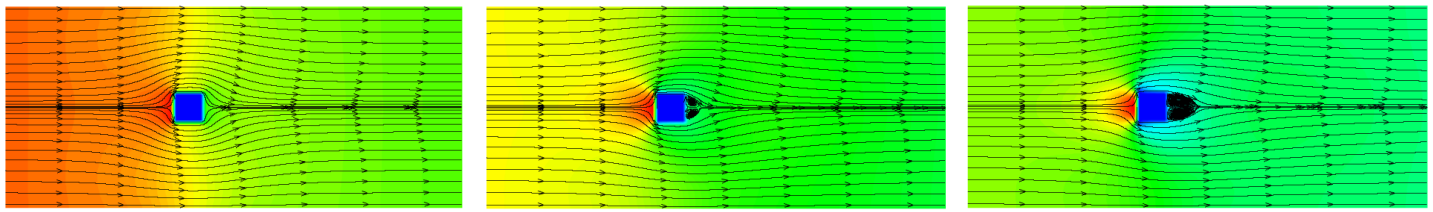
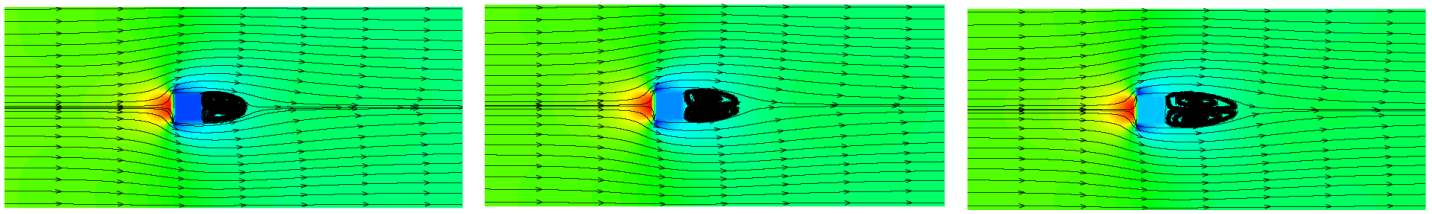


Figure: Vorticity Profiles

Results - Streamlines



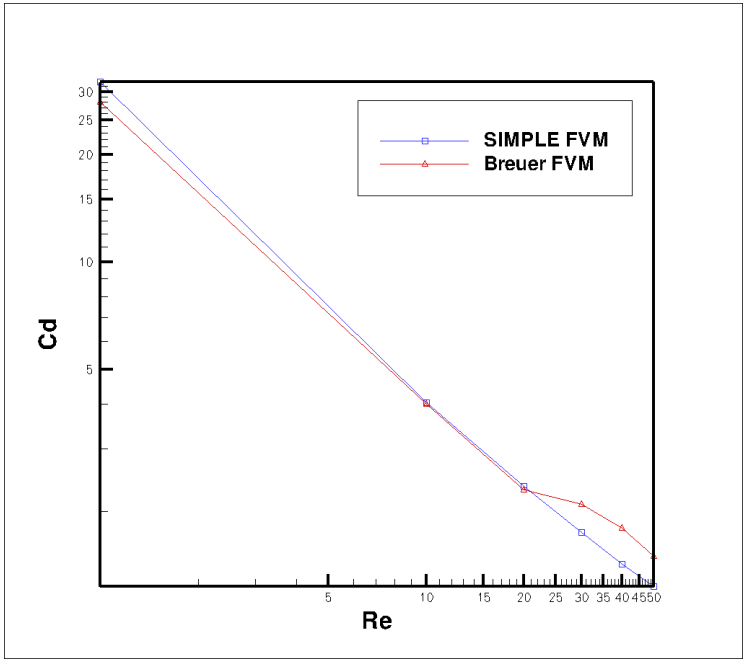
(a) Re 1 (b) Re 10 (c) Re 20



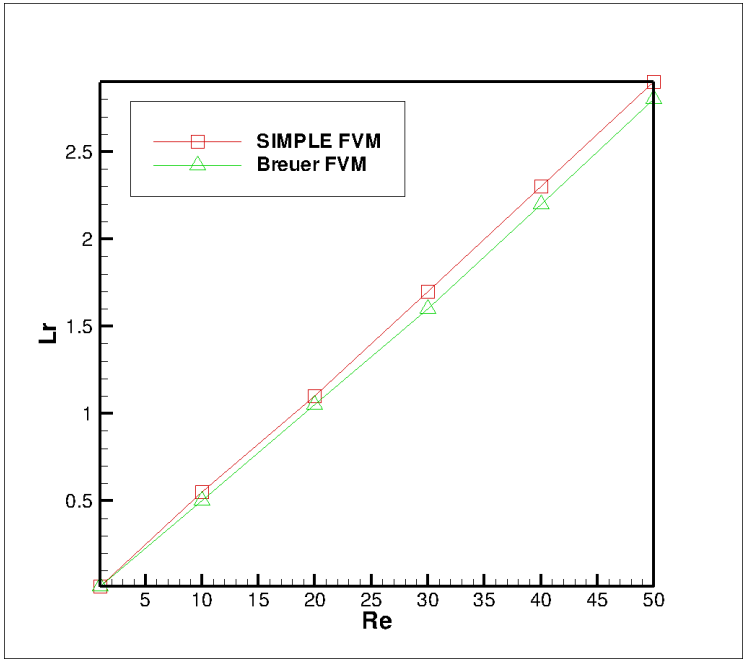
(d) Re 30 (e) Re 40 (f) Re 50

Figure: Streamlines

Validation



(a) Coefficient of Drag



(b) Recirculation Length

Figure: Reynolds Number vs Coefficient of Drag and Recirculation Length

Summary

Closure

- Laminar 2D flow over a square cylinder was simulated using SIMPLE solver
- Validated against published results with good agreement

References

- ME 608 Class Notes
- Accurate computations of the laminar flow past a square cylinder based on two different methods: lattice-Boltzmann and finite-volume by: M. Breuer, J. Bernsdorf, T. Zeiser, F. Durst
  International Journal of Heat and Fluid Flow