CFD Assignment -3

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Fluids and Thermal

Problem

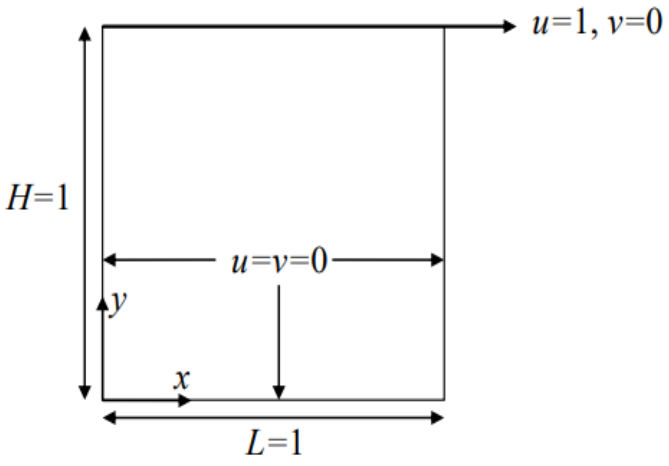
Solve the following partial differential equation using the finite difference method with the specified boundary conditions for the geometry with **100×100** grid size as shown in the figure.

$$\frac{\partial^2\psi}{\partial x^2}+\frac{\partial^2\psi}{\partial y^2}=-\omega$$

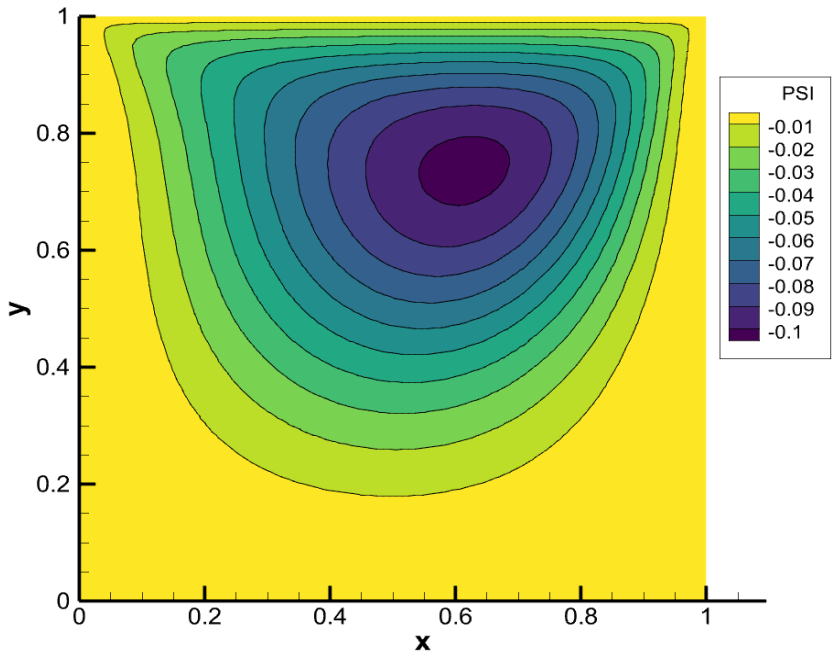
$$u\frac{\partial\omega}{\partial x}+v\frac{\partial\omega}{\partial y}=\frac{1}{\mathrm{Re}}\left(\frac{\partial^2\omega}{\partial x^2}+\frac{\partial^2\omega}{\partial y^2}\right)$$

$$u=\frac{\partial\psi}{\partial y}\ ,\quad v=-\frac{\partial\psi}{\partial x}$$

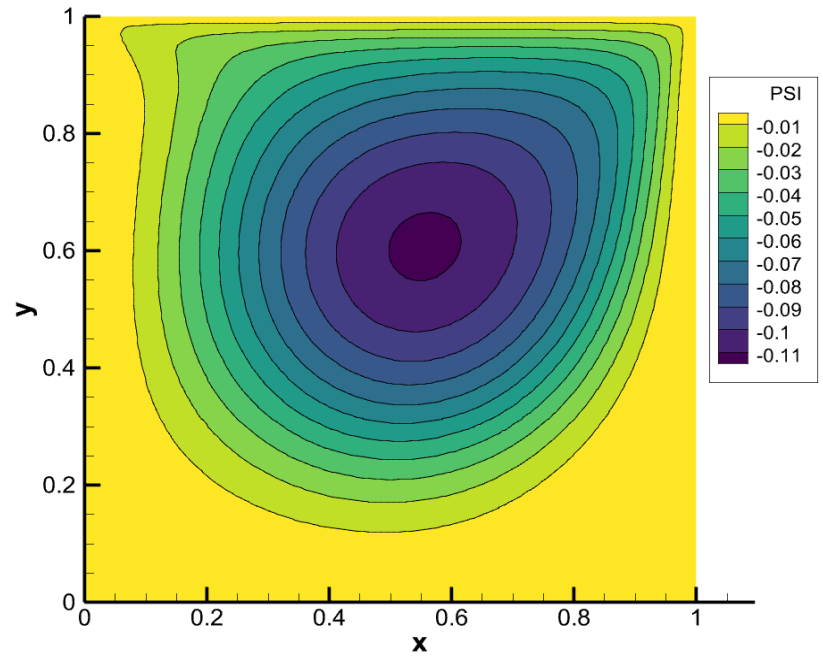
Convergence Criteria: Find the maximum error of stream function and vorticity and reduce that maximum error to 10^{-6}. Apply the finite difference discretization to replace all derivatives with the corresponding central difference expressions with uniform grid $M \times N$ and *write the discretized equations of the governing equations and boundary conditions of stream function & vorticity in the* ***report***. Write the code in such a way so that you can input the values of Re, M, N. Submit the results and discussion for **Re=100 and 400** in terms of streamlines, velocity vectors, u velocity along vertical centerline and v velocity along horizontal centerline.



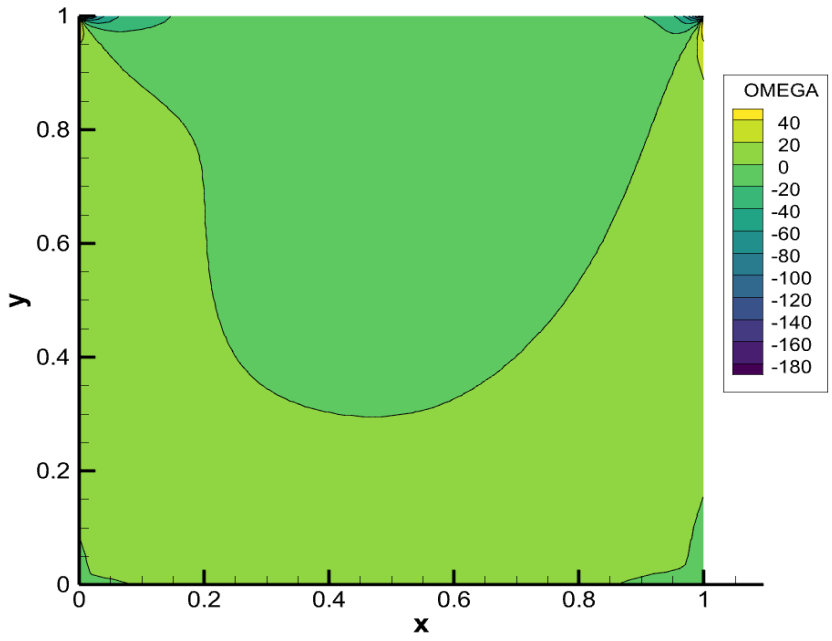
Re = 100 ; Grid Size = 100 × 100 ; Stream Line Graph



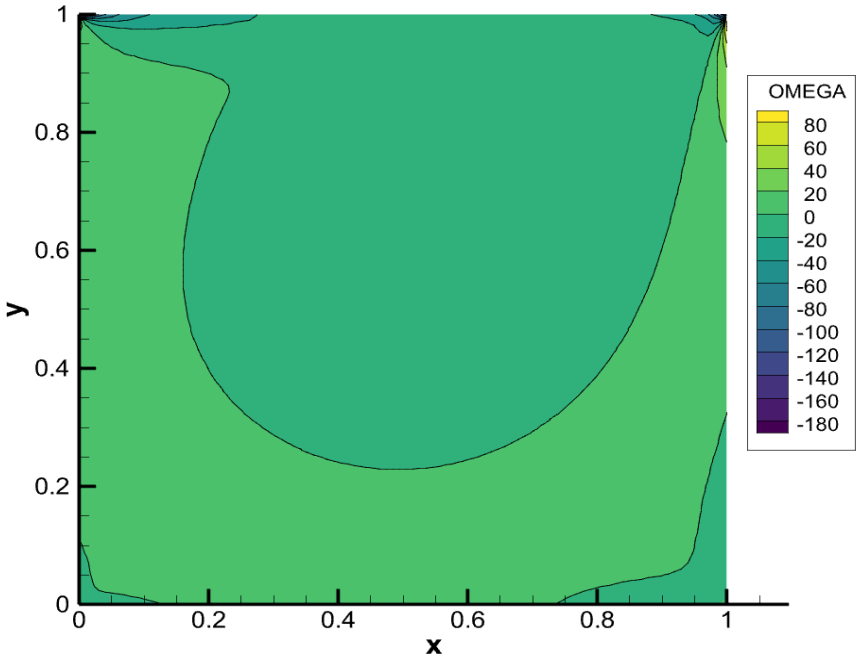
Re = 400 ; Grid Size = 100 × 100 ; Stream Line Graph



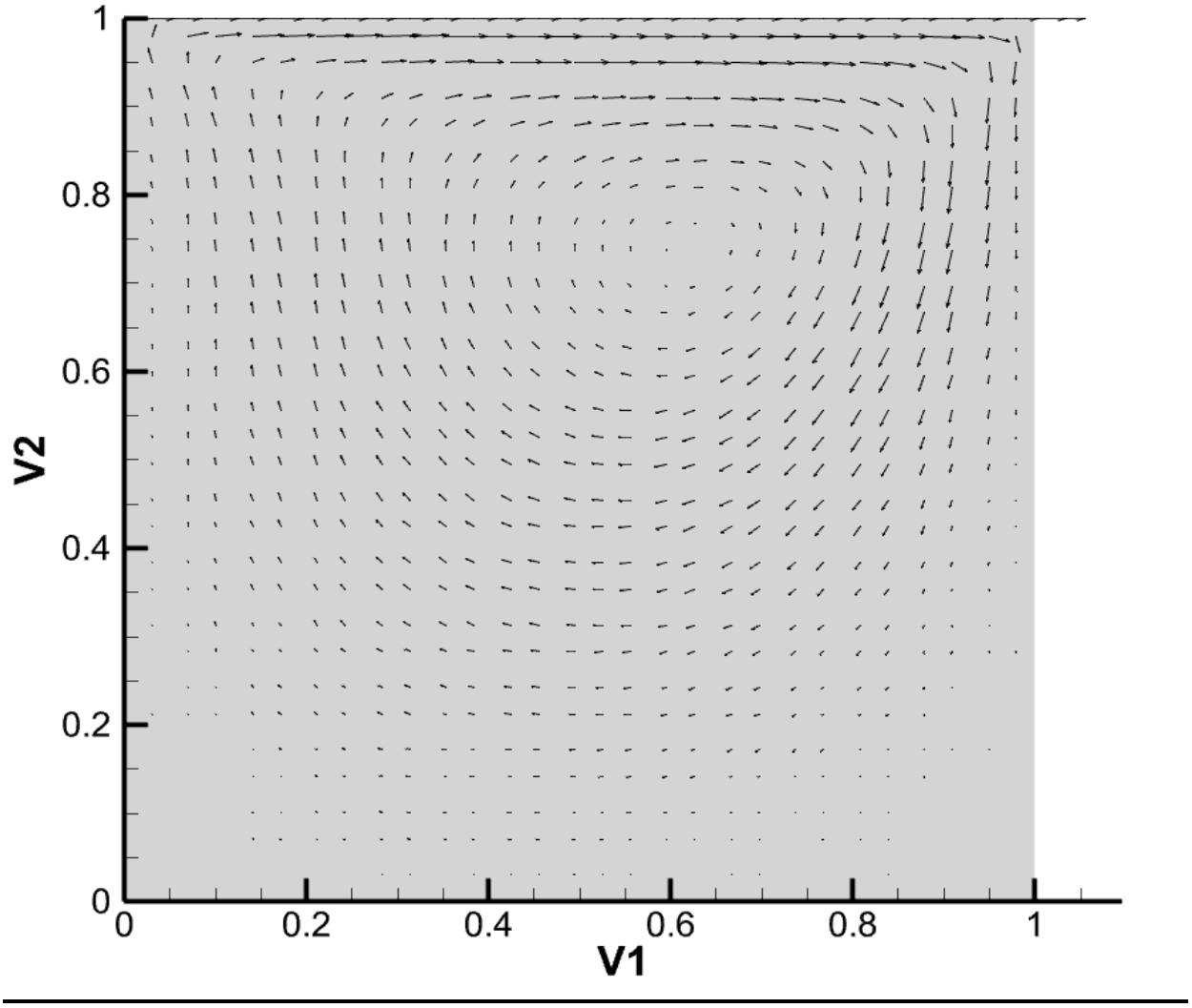
Re = 100 ; Grid Size = 100 × 100 ; Vorticity (omega)



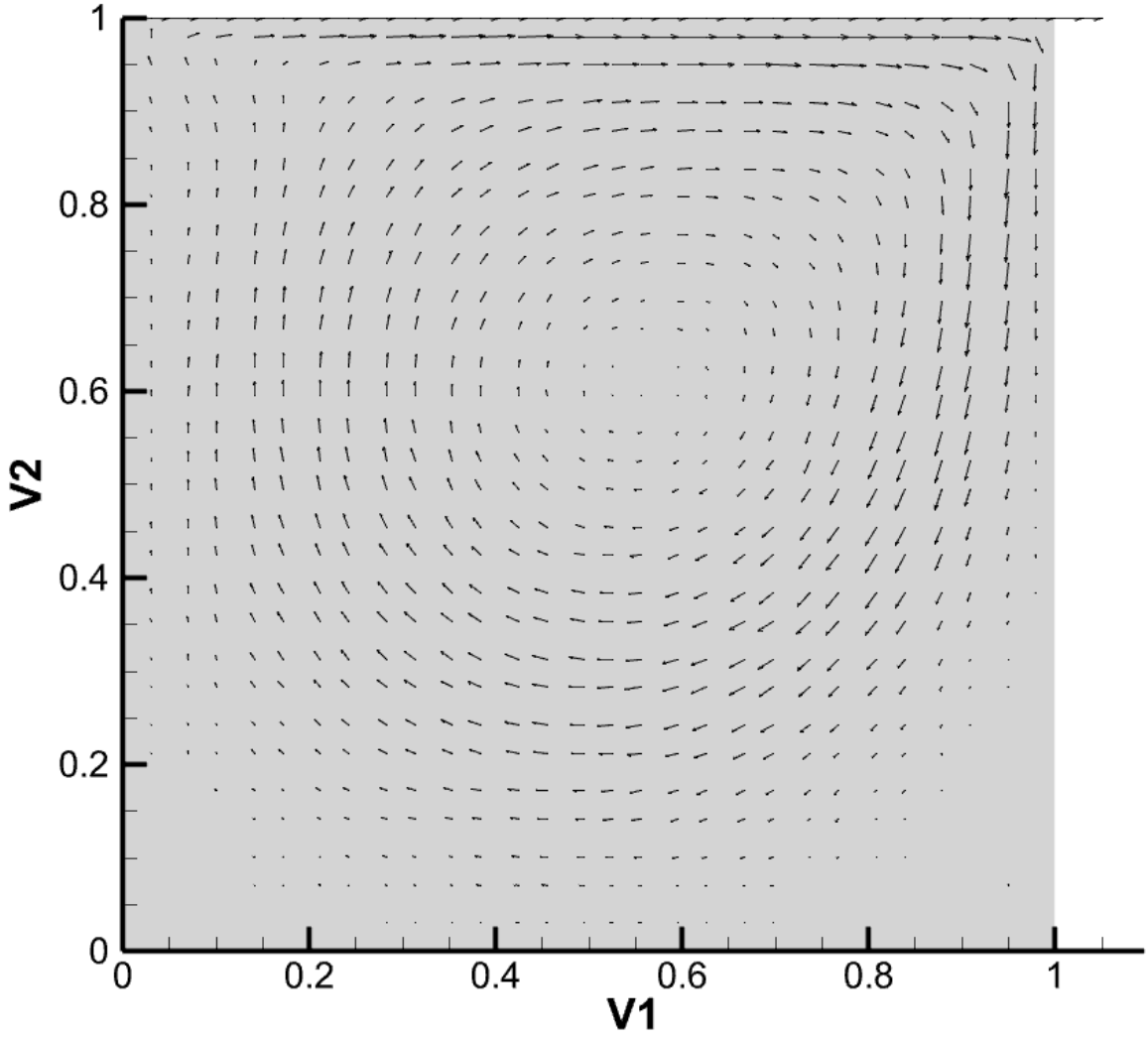
Re = 400 ; Grid Size = 100 × 100 ; Vorticity(omega)



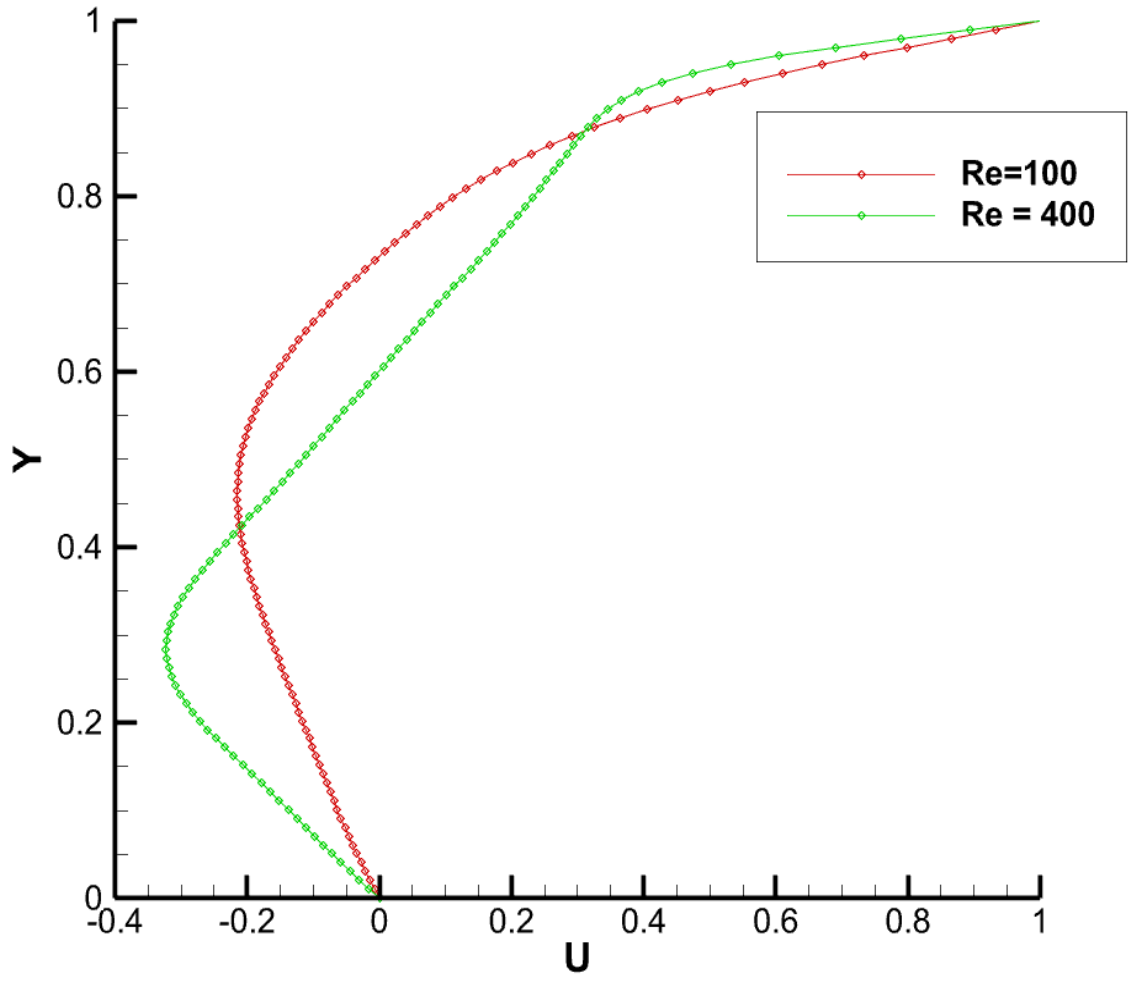
Re = 100 ; Grid Size = 100 × 100 ; Velocity Vector graph



Re = 400 ; Grid Size = 100 × 100 ; Velocity Vector graph



Centerline velocity (U)



Center line velocity (V)