

COMPUTATIONAL FLUID DYNAMICS
ASSIGNMENT-3



Submitted by,

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COMPUTATIONAL MECHANICS

QUESTION 1

Discretization of the governing equations:

- Discretized equation of stream function:

$$\varphi_{i,j} = \frac{\varphi_{i+1,j} + \varphi_{i-1,j} + \beta^2(\varphi_{i,j+1} + \varphi_{i,j-1}) + \Delta x^2 \omega_{i,j}}{2(1 + \beta^2)}$$

- Discretized equation of vorticity:

$$\omega_{i,j} = \frac{\omega_{i+1,j} + \omega_{i-1,j} + \beta^2(\omega_{i,j+1} + \omega_{i,j-1}) - \frac{1}{4}\beta Re(\omega_{i+1,j} - \omega_{i-1,j})(\varphi_{i,j+1} + \varphi_{i,j-1}) + \frac{1}{4}\beta Re(\omega_{i,j+1} - \omega_{i,j-1})(\varphi_{i+1,j} - \varphi_{i-1,j})}{2(1 + \beta^2)}$$

Boundary Conditions:

- Boundary conditions for stream function(ϕ):

Vertical walls: For $1 \leq j \leq j_{max}$, $\varphi_{1,j} = \varphi_{i_{max},j} = 0$

Horizontal walls: For $1 \leq i \leq i_{max}$, $\varphi_{i,1} = \varphi_{i,j_{max}} = 0$

- Boundary conditions for vorticity(ω):

Wall-vorticity at the left side-wall,

$$\omega_{1,j} = -\frac{2\varphi_{2,j}}{(\Delta x)^2} \text{ for } 2 \leq j \leq j_{max-1}$$

Wall-vorticity at the right side wall,

$$\omega_{i_{max},j} = -\frac{2\varphi_{i_{max}-1,j}}{(\Delta x)^2} \text{ for } 2 \leq j \leq j_{max-1}$$

Wall-vorticity at the bottom wall,

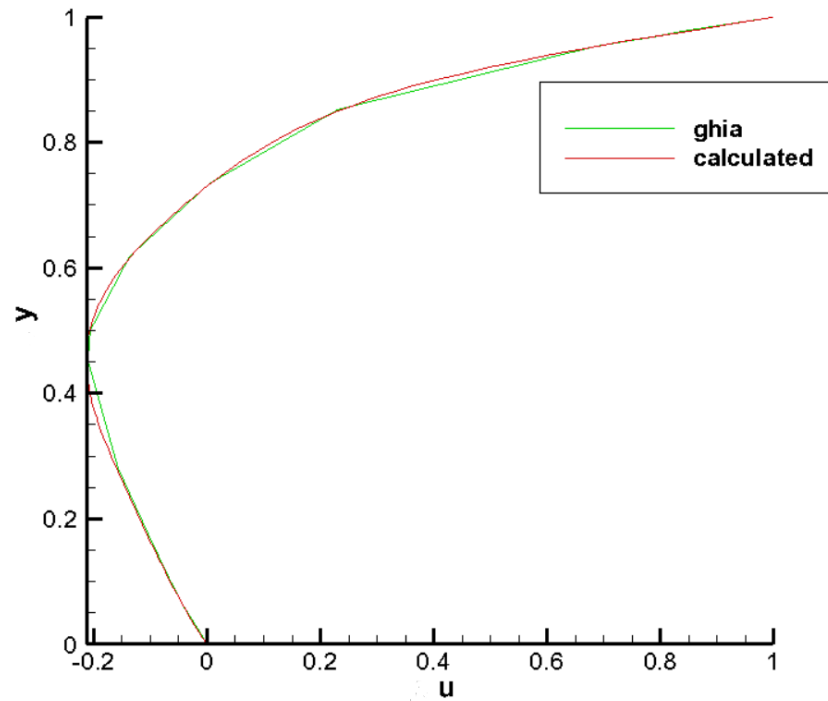
$$\omega_{i,1} = -\frac{2\varphi_{i,2}}{(\Delta y)^2} \text{ for } 2 \leq i \leq i_{max-1}$$

Wall-vorticity at the top wall,

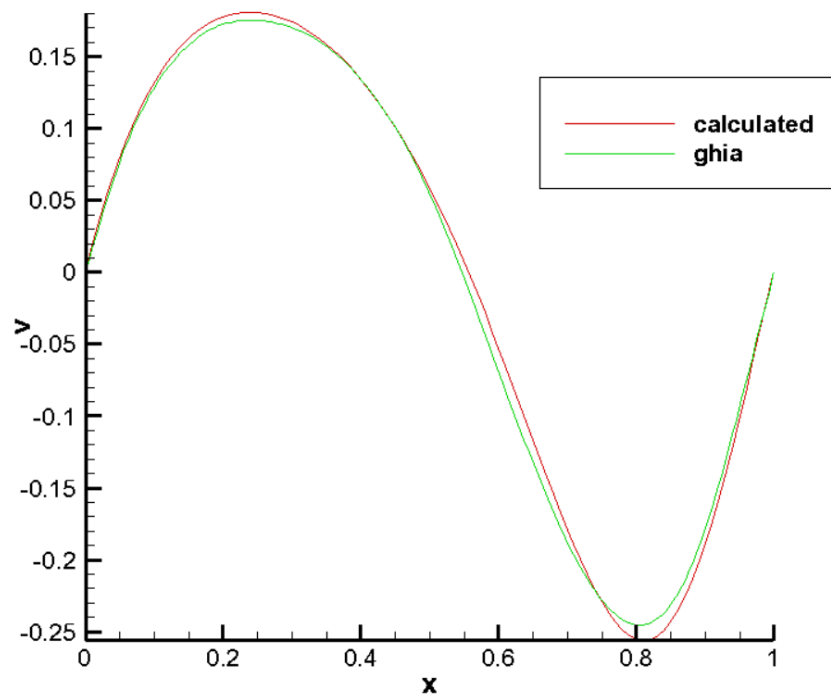
$$\omega_{i,j_{max}} = -\frac{2\varphi_{i,j_{max}-1} + 2\Delta y U}{(\Delta y)^2} \text{ for } 2 \leq i \leq i_{max-1}$$

Part A: For Reynold's Number =100

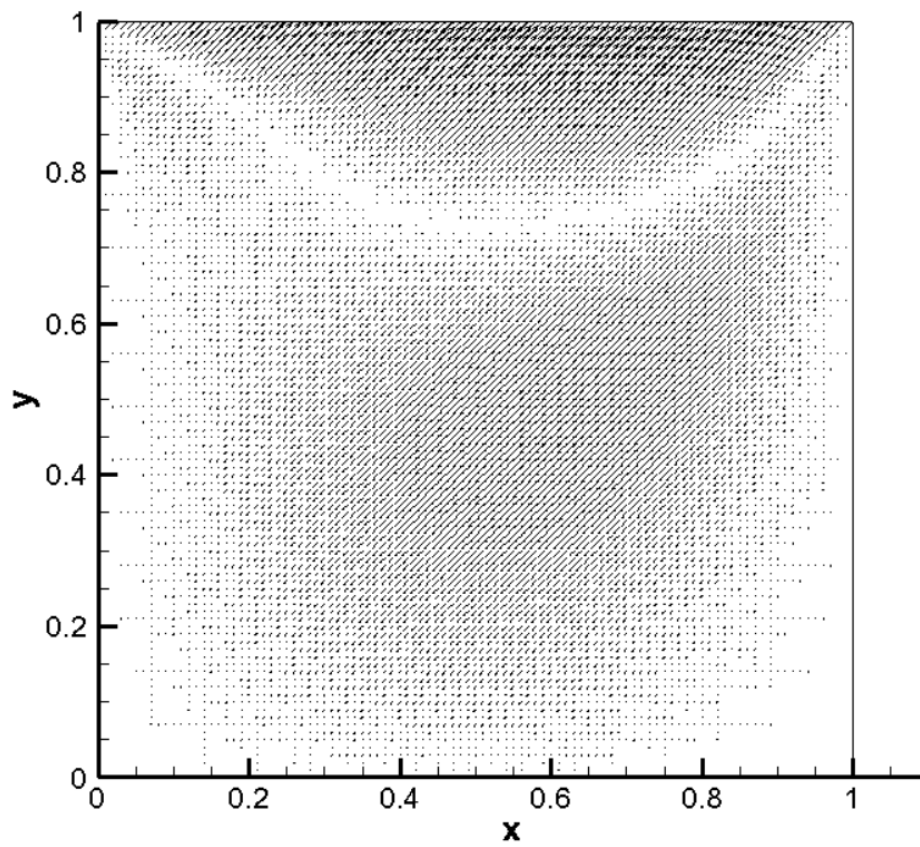
1. Centre Line horizontal velocity(u):



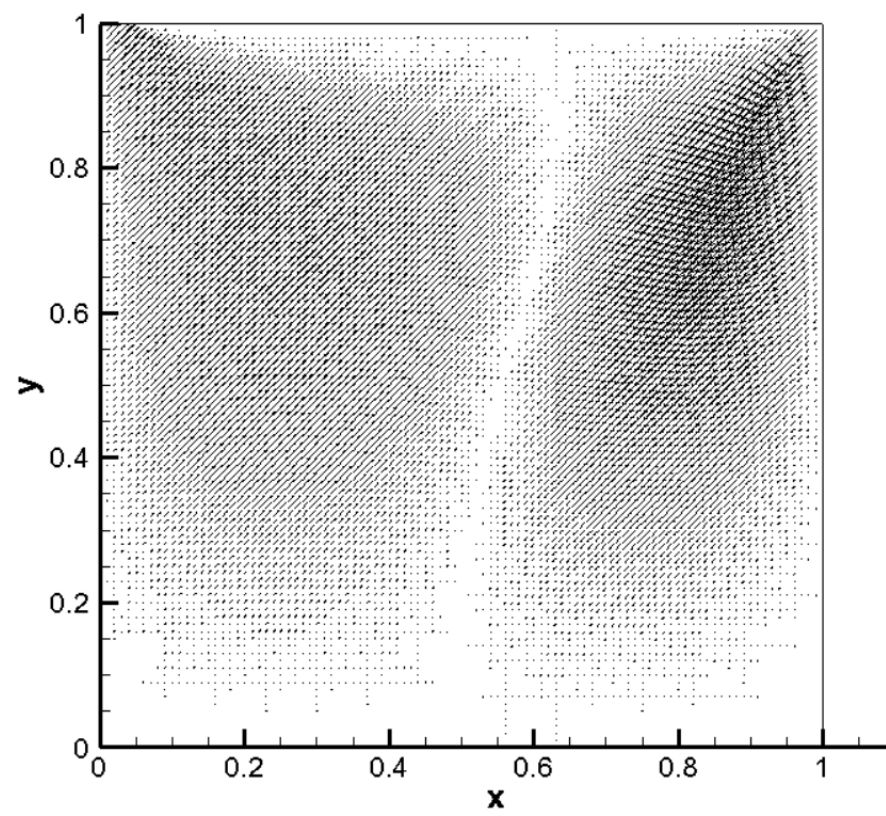
2. Centre Line vertical velocity(v):



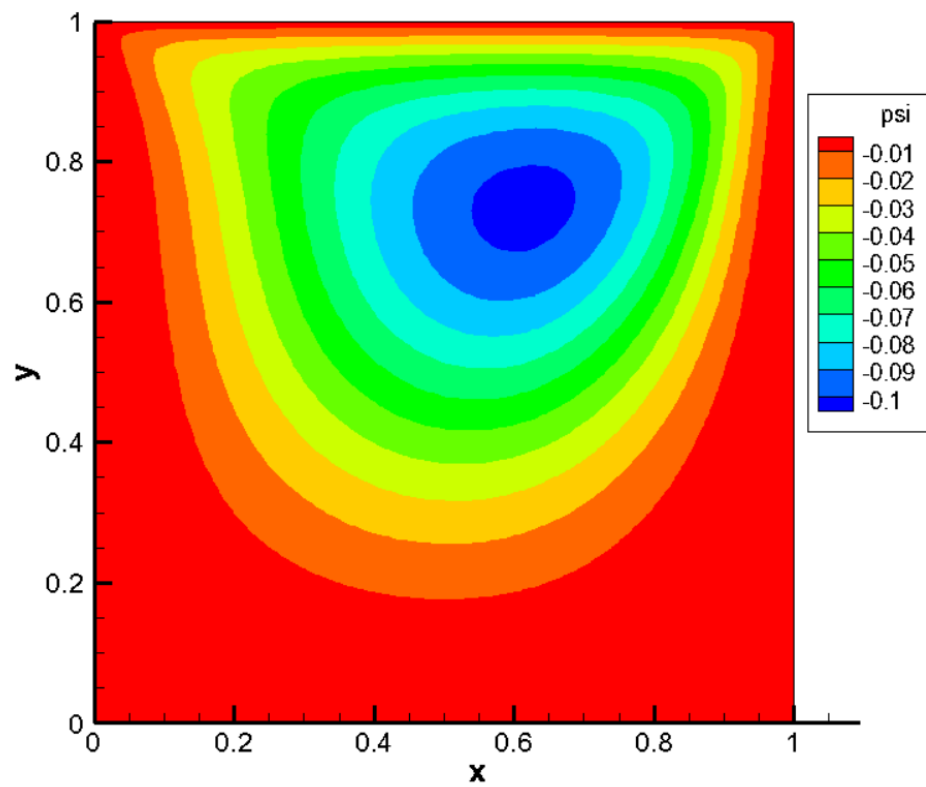
3. U Vector plot:



4. V Vector plot:

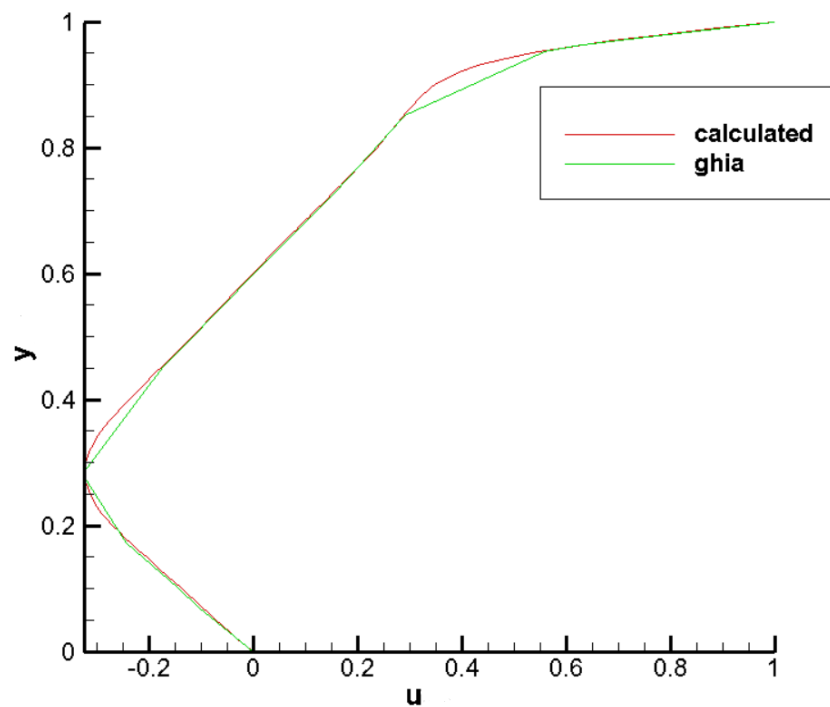


5. Streamline Plot:

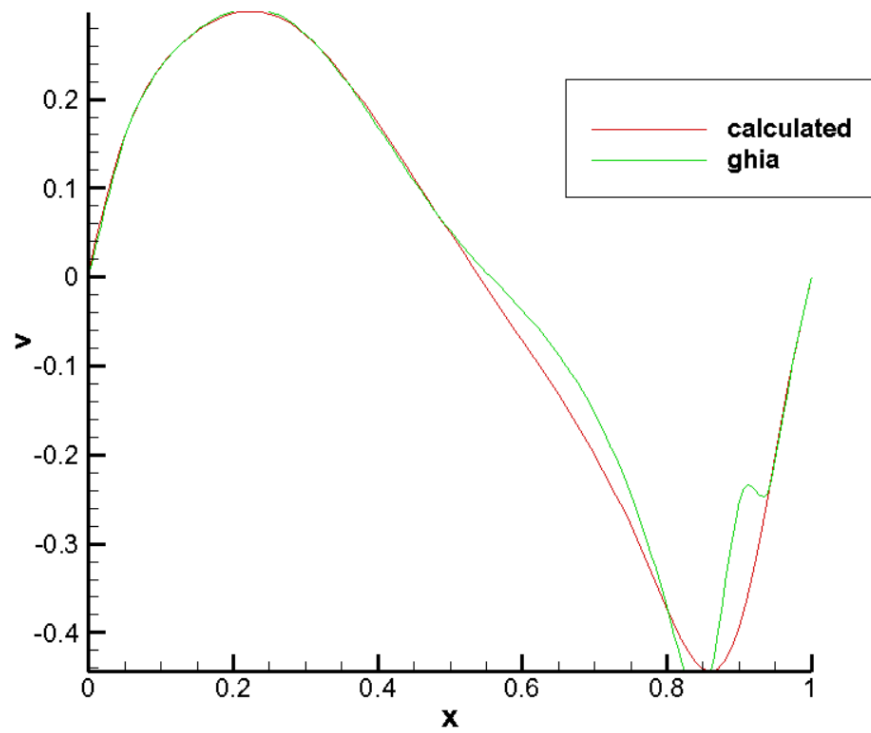


Part B: For Reynold's Number =400

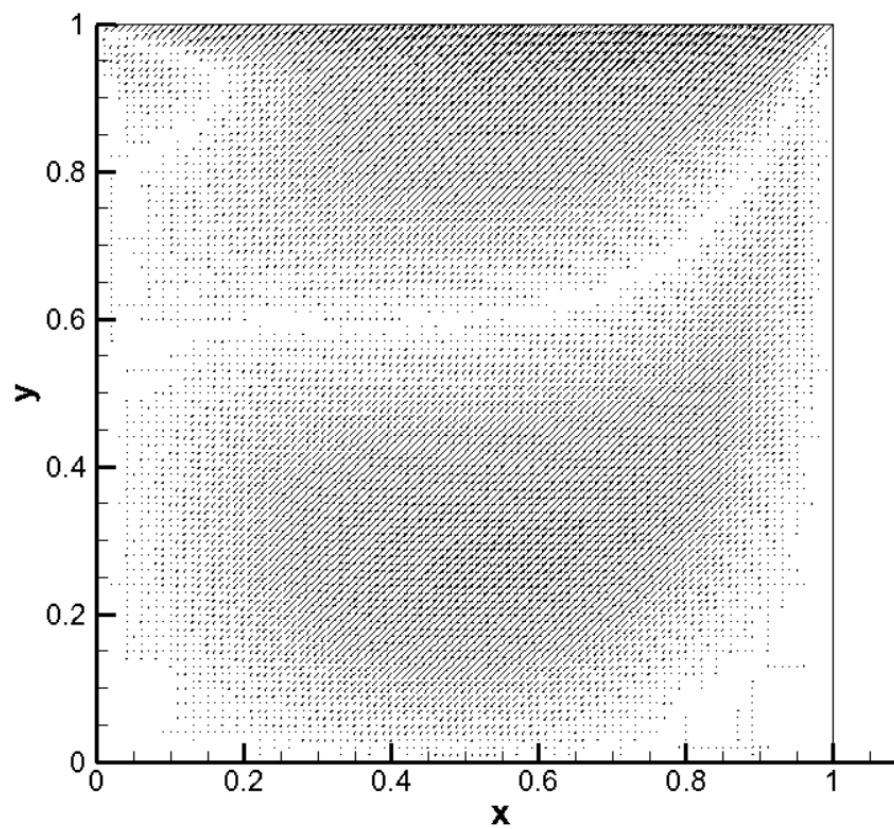
1. Centre Line horizontal velocity(u):



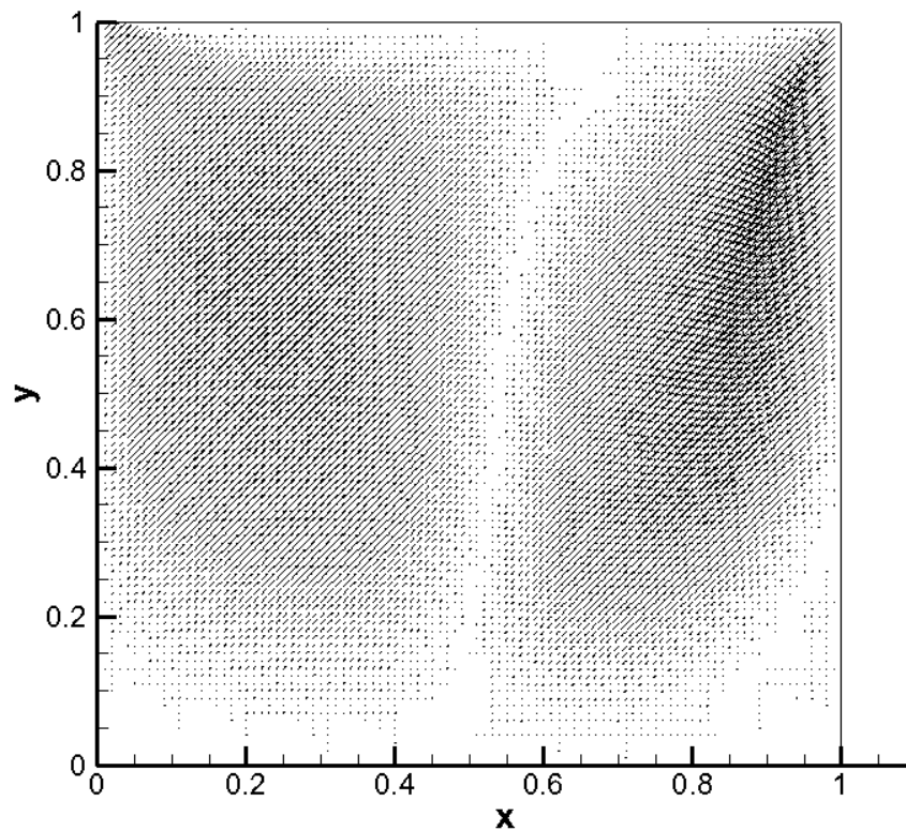
2. Centre Line vertical velocity(v):



3. U Vector plot:



4. V Vector plot:



5. Streamline Plot:

