Lokesh kumar verma
Roll no. 224103314

INDIAN INSTITUTE OF TECHNOLOGY , GUWAHATI

COMPUTATIONAL FLUID DYNAMICS

ASSIGNMENT – 03

LID DRIVEN CAVITY PROBLEM

submitted by :- lokesh kumar verma

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(fluid and thermal)

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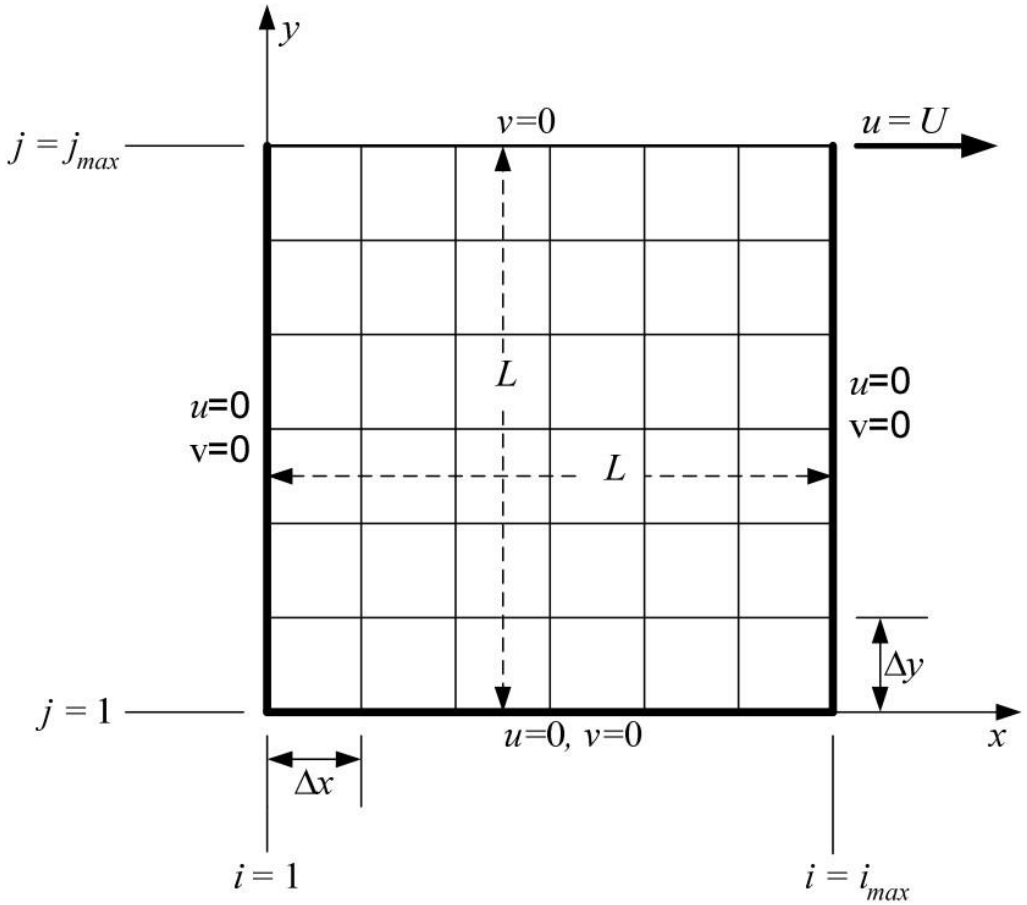

Discretization of the governing equations:

- **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):**

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

- **Boundary conditions for vorticity(ω):**

Wall-vorticity at the left side-wall,

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

Wall-vorticity at the right side wall,

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

Wall-vorticity at the bottom wall,

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

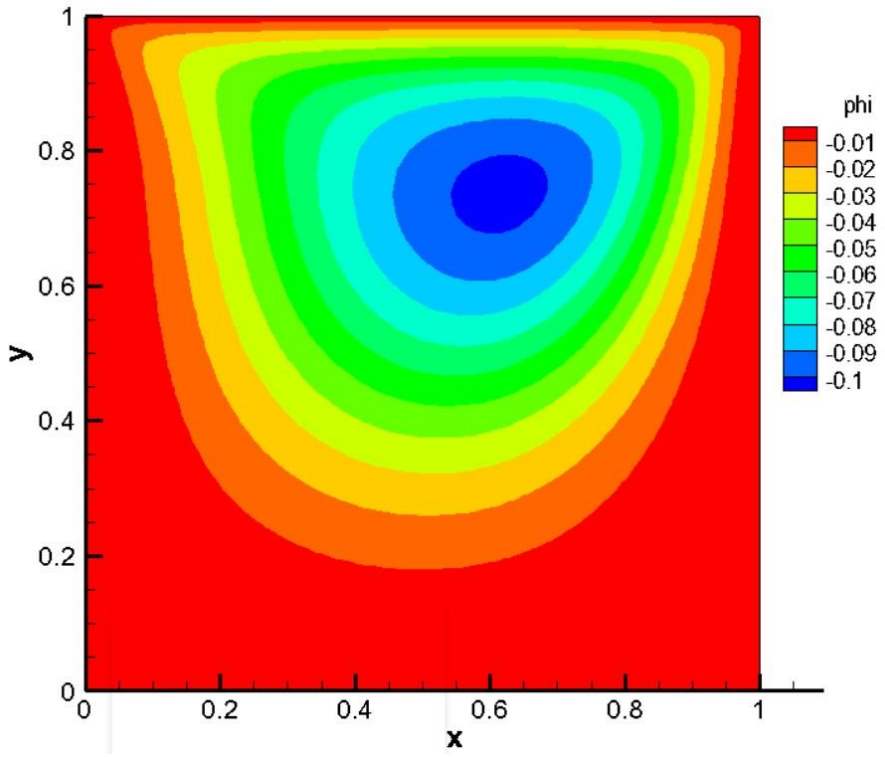
Wall-vorticity at the top wall,

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

CASE I

For Reynolds number=100 the obtained results from the program are as follows:

(i) contour plot



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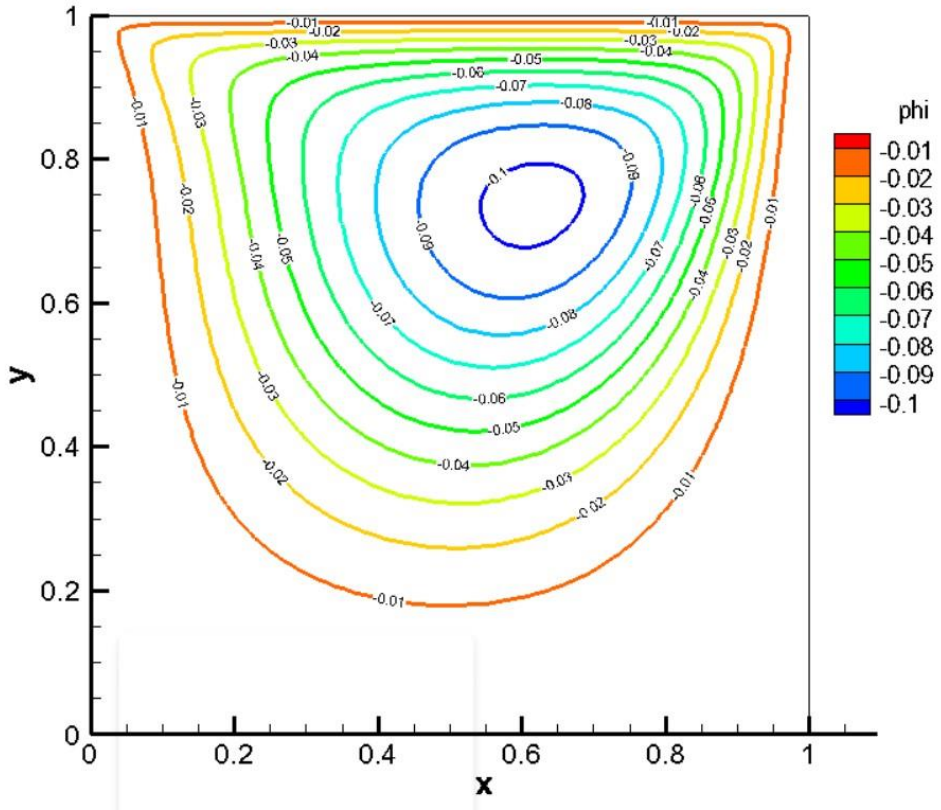
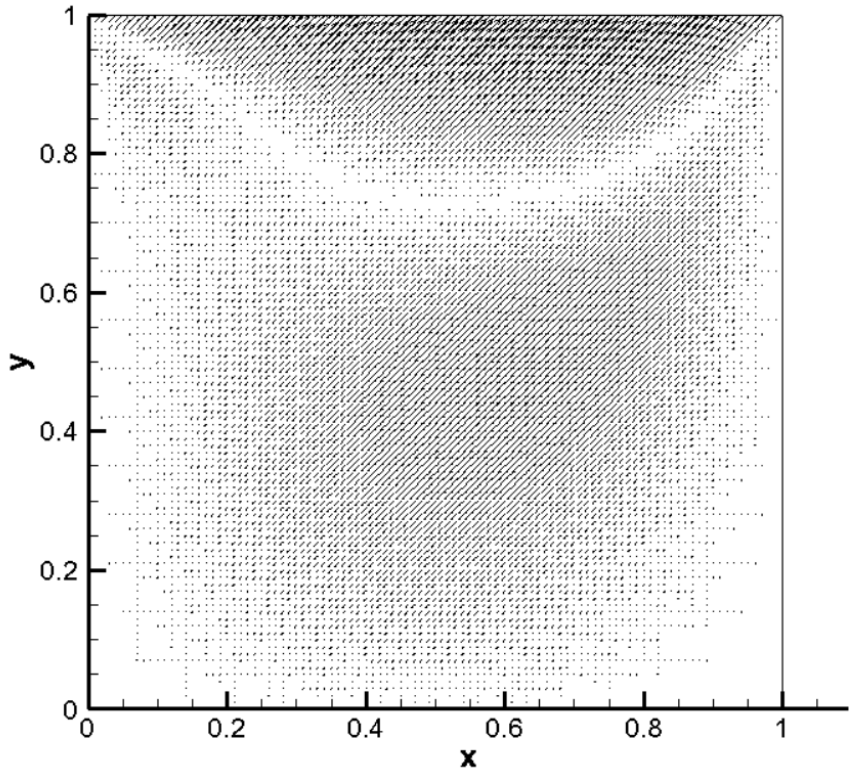


(ii) U-velocity vectors plot



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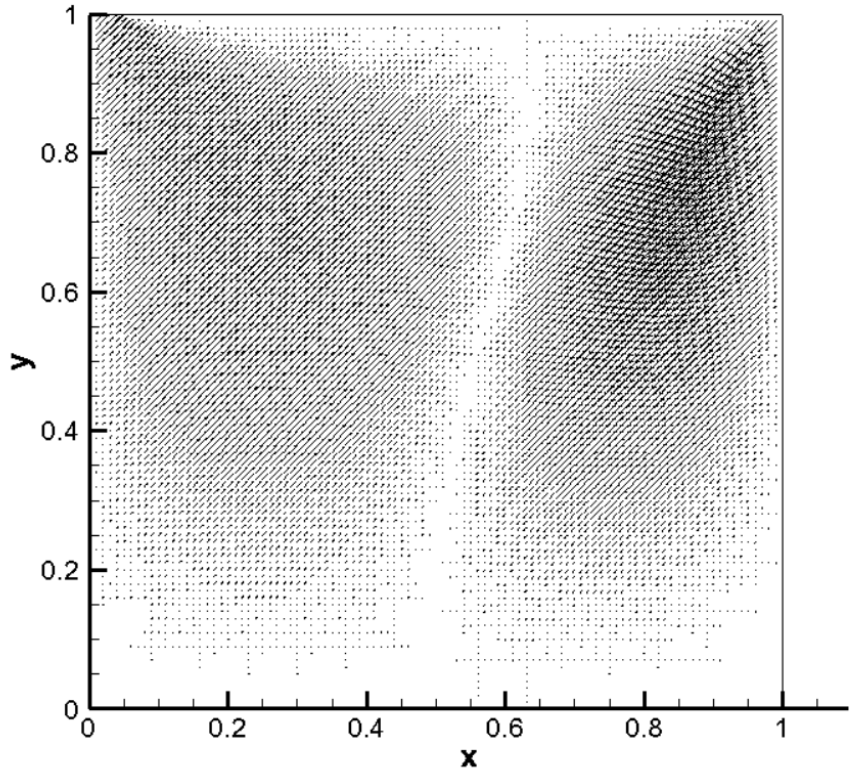
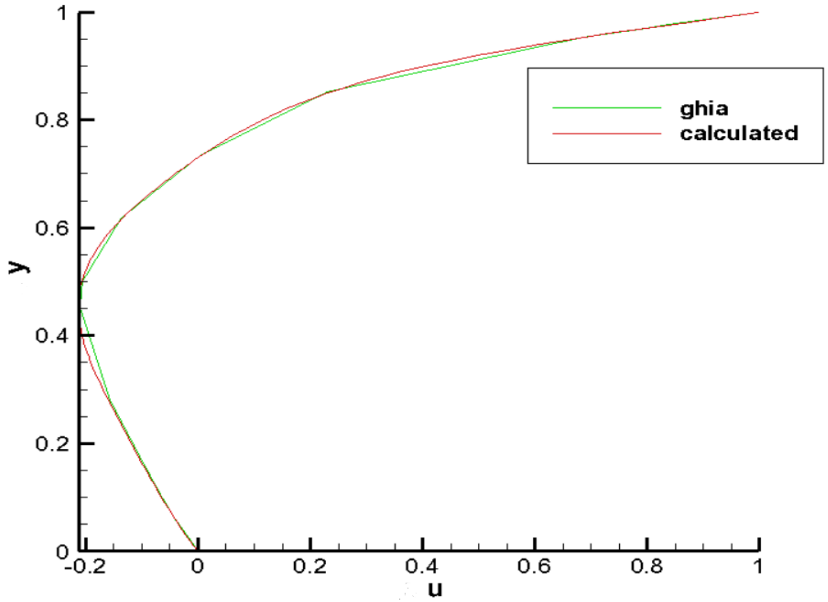
(iii) V-velocity vectors plot



(iv) comparison graph between the obtained results of u with the standard ghia results:



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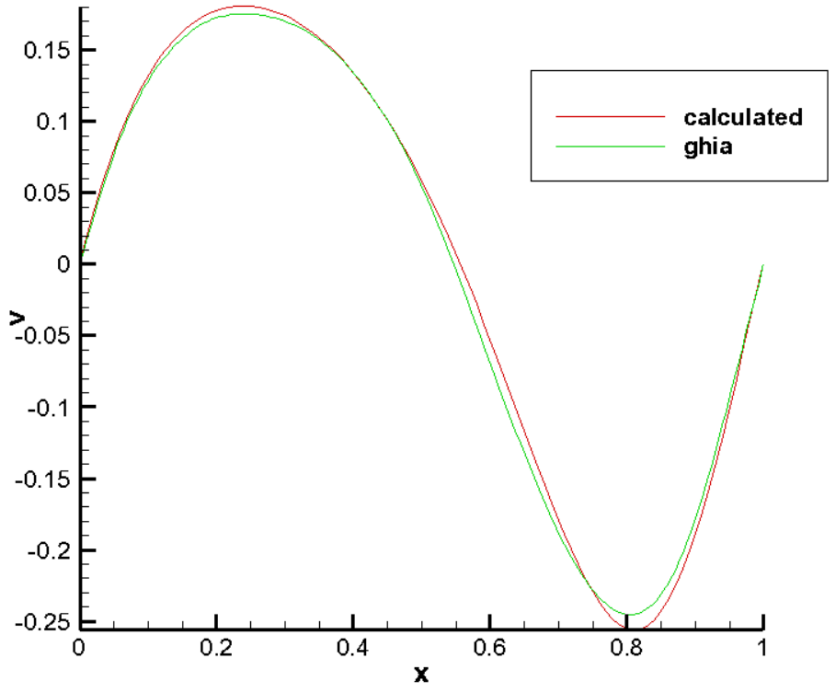
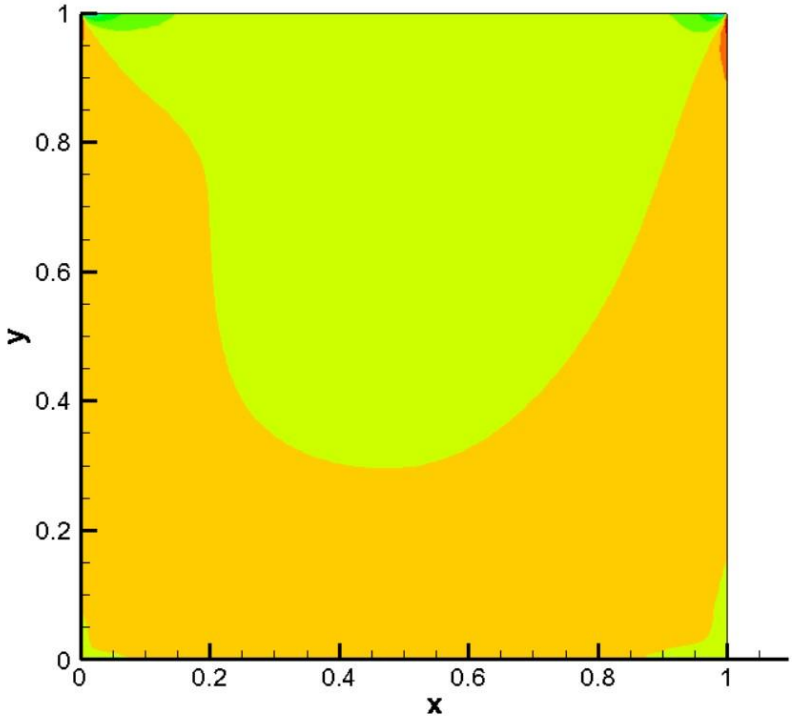
(v) comparison graph between the obtained results of v with the standard ghia results:



(vi) The vorticity contour plot is obtained as shown below



(vii) Iterations for convergence

No of iterations required for convergence in calculating the stream function and omega values so as to have the error reduced to a maximum of 0.00001 were 7655.

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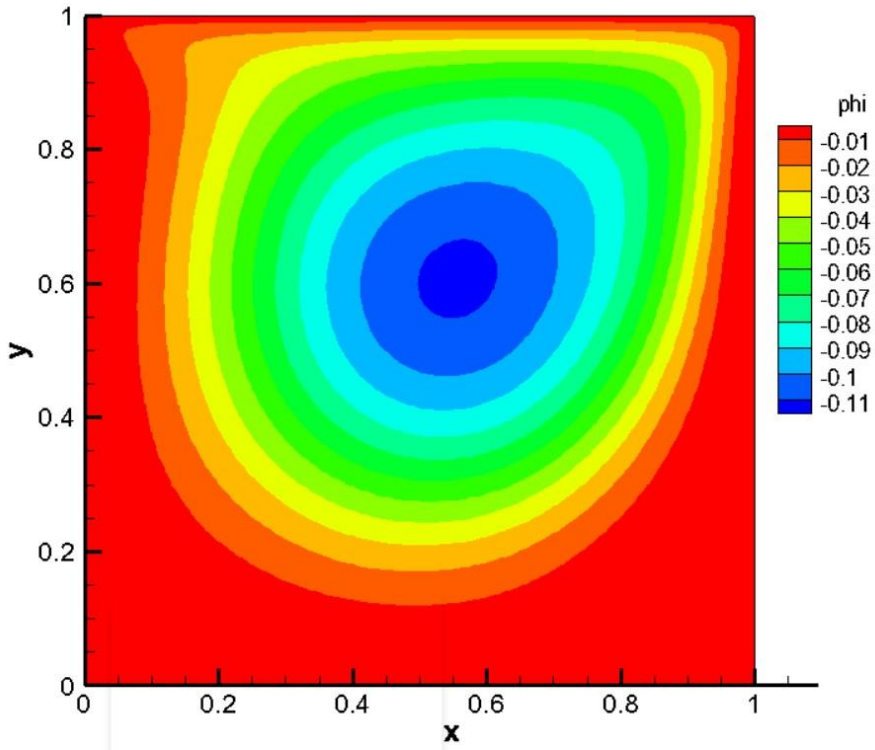
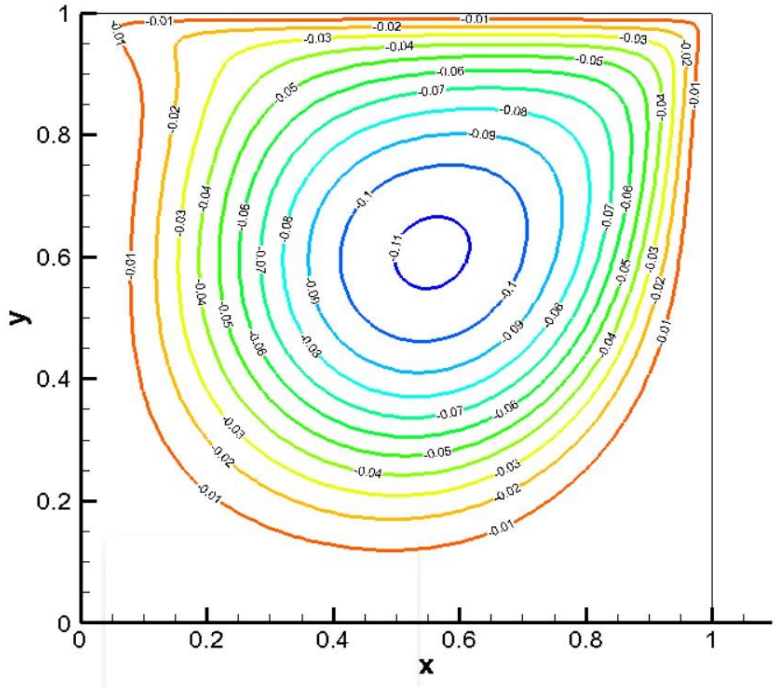
CASE-II

For Reynolds number=100 the obtained results from the program are as follows:

(i) contour plot





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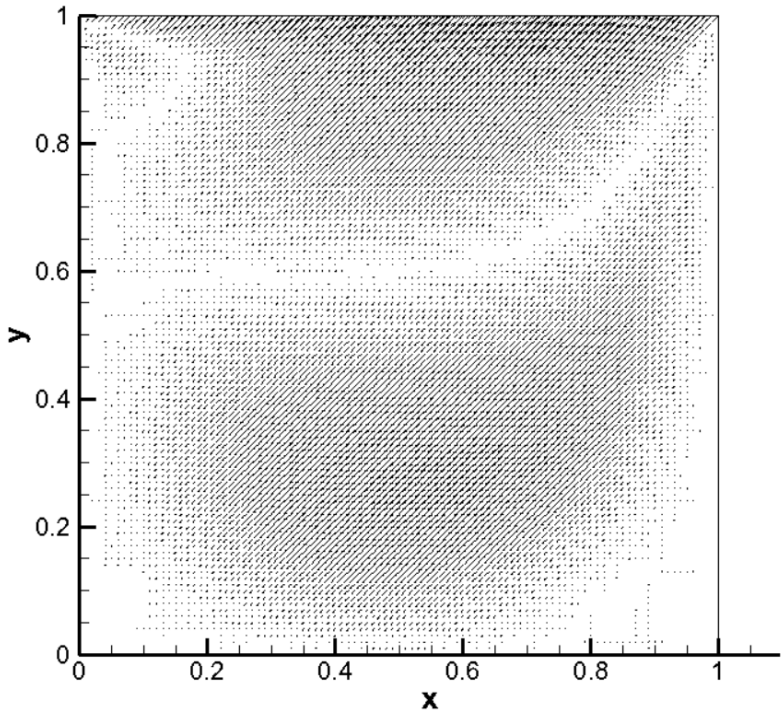
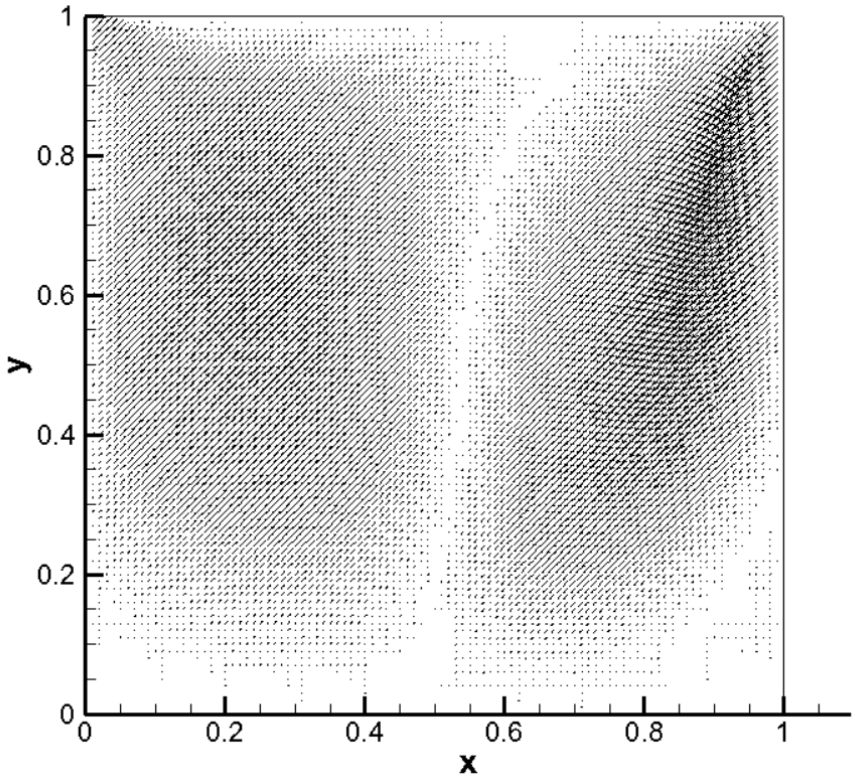
(i) U-velocity vectors plot



(ii) V-velocity vectors plot



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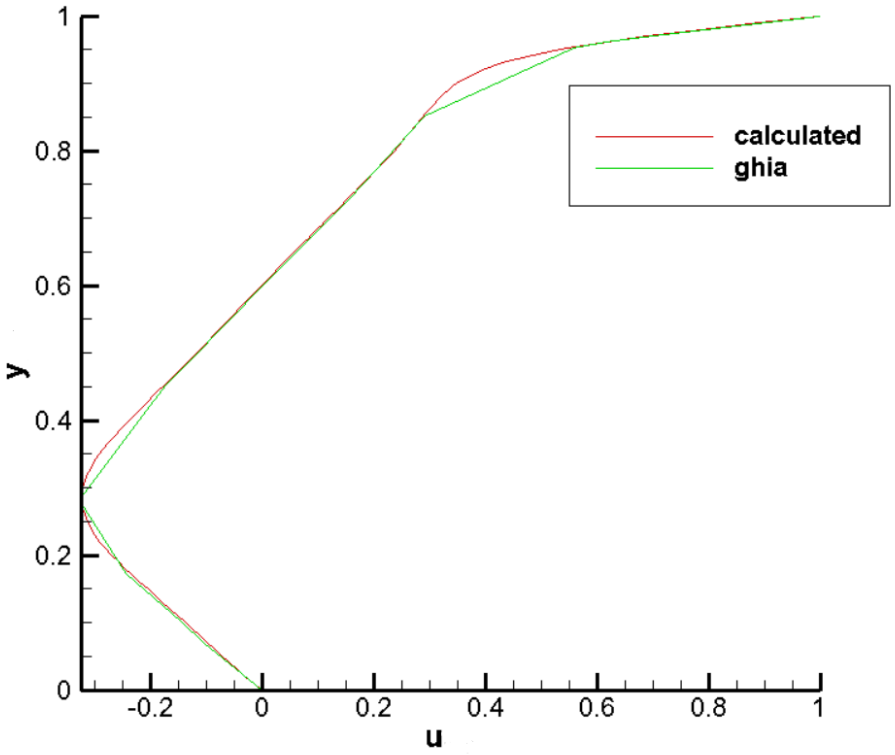
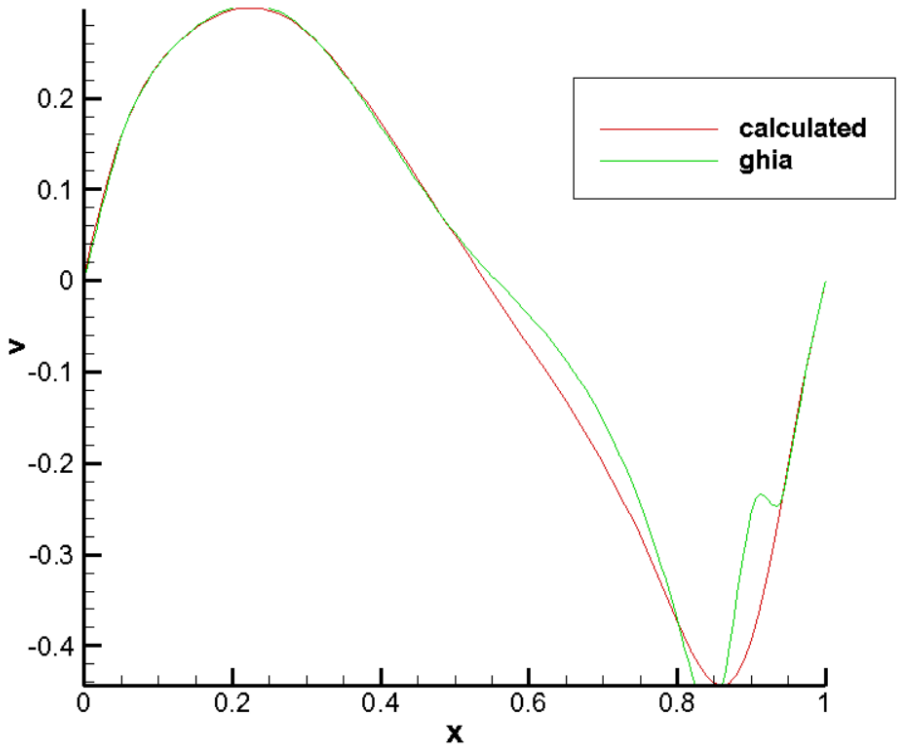
(iii) comparison graph between the obtained results of u with the standard ghia results



(iv) comparison graph between the obtained results of v with the standard ghia results



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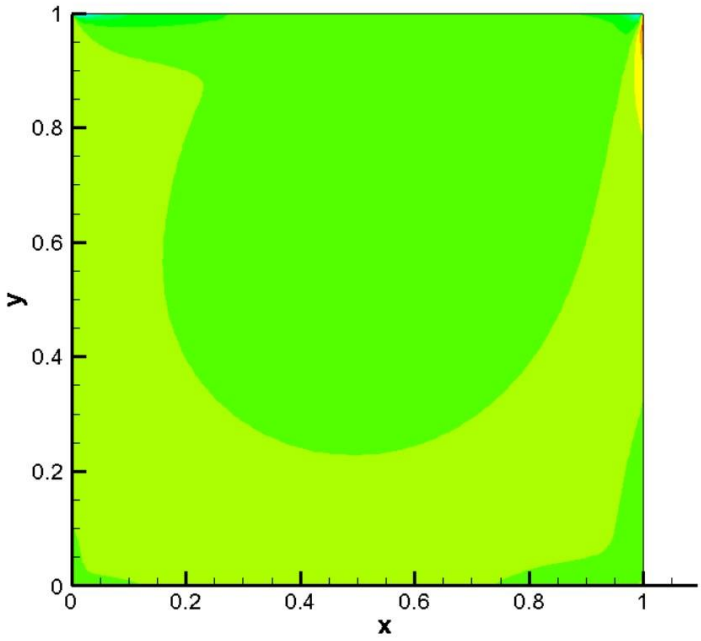
(v) The vorticity contour plot is obtained as shown below



(vi) Iterations for convergence

No of iterations required for convergence in calculating the stream function and omega values so as to have the error reduced to a maximum of 0.00001 were 5548.