Computer Assignment 3A

Submitted by

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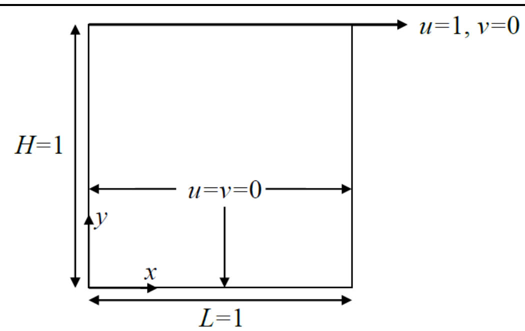
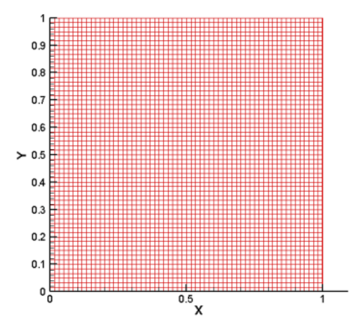
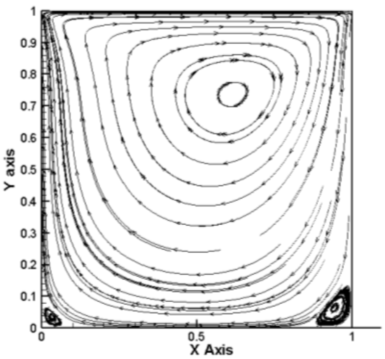
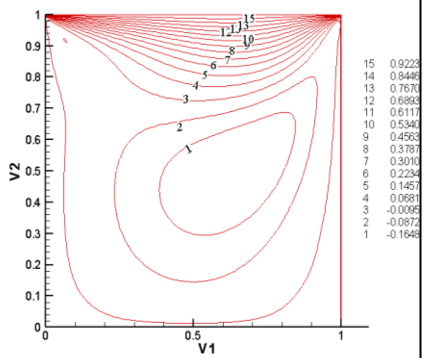
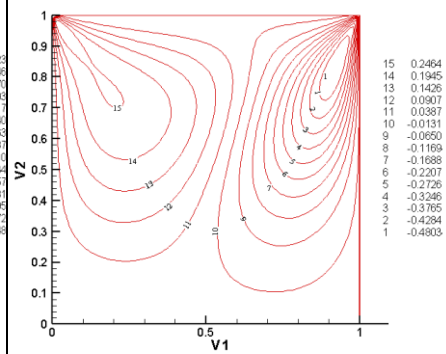
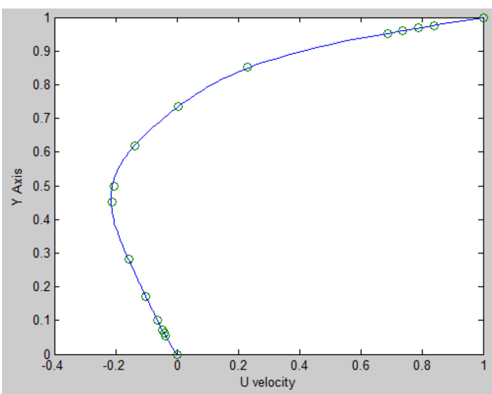
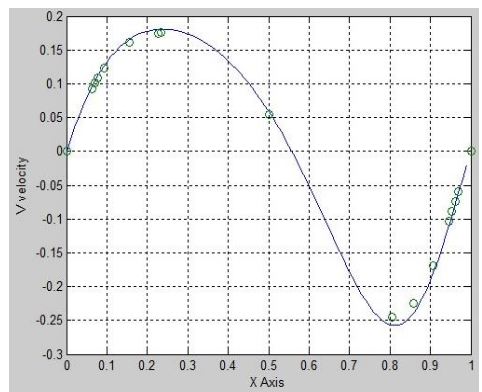
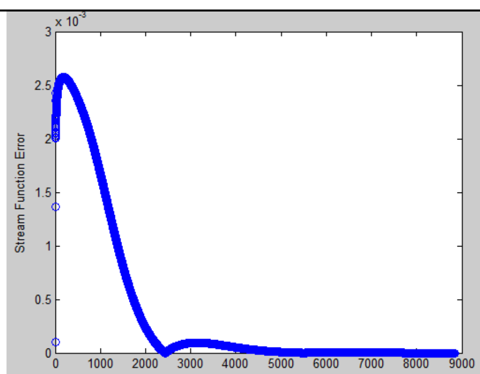
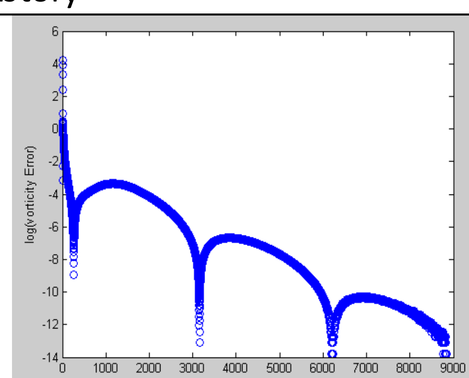
Tabulation of discretised algebraic equation	
Discretised Equation for Solving Stream Function	$\Psi_{i,j+1} + \Psi_{i,j-1} + \beta^2\Psi_{i+1,j} + \beta^2\Psi_{i-1,j} + (\Delta x)^2\omega_{i,j} = 2(1+\beta^2)\Psi_{i,j}$
Discretised Equation for U-V Update	$U = (\Psi i_{+1,j} - \Psi_{i-1,j})/(2\Delta y)$ $V = -(\Psi i,j_{-1} - \Psi_{i,j+1})/(2\Delta x)$
Discretised Equation for Vorticity BCs update	$\omega_{i,0} = -(2/\Delta x^2)(\Psi_{i,1} - \Psi_{i,0})$ $\omega_{i,M-1} = -(2/\Delta x^2)(\Psi_{i,M-2} - \Psi_{i,M-1})$ $\omega_{N-1,j} = -(2/\Delta y^2)(\Psi_{N-2,j} - \Psi_{N-1,j})$ $\omega_{0,j} = -(2/\Delta y^2)(\Psi_{1,j} - \Psi_{0,j} + U\Delta y)$
Discretised Equation for Solving for Vorticity	$2(1+\beta^2)\,\omega_{i,j} = (1-\frac{Re^*\Delta x^*U_{i,j}}{2})\omega_{i,j+1} + (1+\frac{Re^*\Delta x^*U_{i,j}}{2})\omega_{i,j-1} + \beta^2(1-\frac{Re^*\Delta y^*V_{i,j}}{2})\omega_{i+1,j} + \beta^2(1+\frac{Re^*\Delta y^*V_{i,j}}{2})\omega_{i-1,j}$

Problem Definition	Discretised Domain
 **Figure:** Flow inside a lid-driven cavity	

Tabulation of Results for Re 100 on a 101x101 grid		
Streamlines	U velocity Contours	V velocity Contours
		

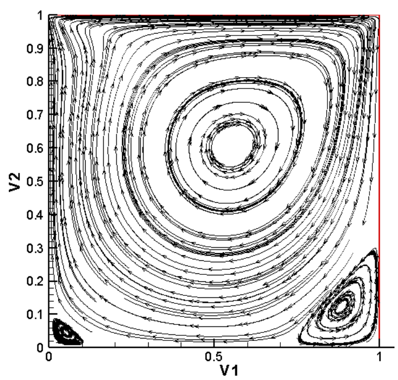
Tabulation of Validation Results	
Y vs. U at horizontal centerline	V vs. X at vertical centerline
	

Convergence History	
	

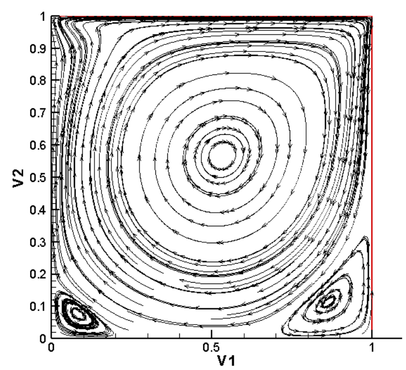
Discussion:

The code developed for this problem was tested for higher values of Reynolds number and following points were observed:

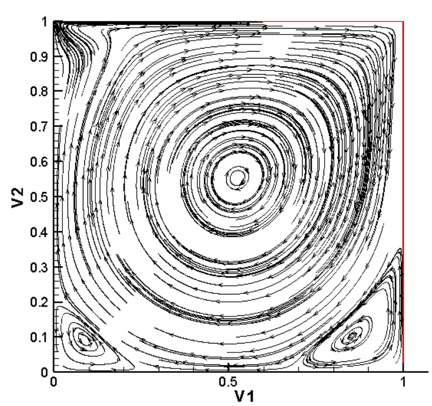
- Primary vortex at Re=100 is formed near the top right corner of the cavity. This move to the geometric center of the cavity with increase in Re.
- Secondary vortices are formed near the bottom left and right corner of the cavity at Re=100.
- With increase of Re the size of vortex also increases and their centers too move towards the geometric center.
- At Re = 3200, a third vortex is formed at top left corner of the cavity.
- Finer grids are required with relaxation scheme to capture the formation of the secondary vortices



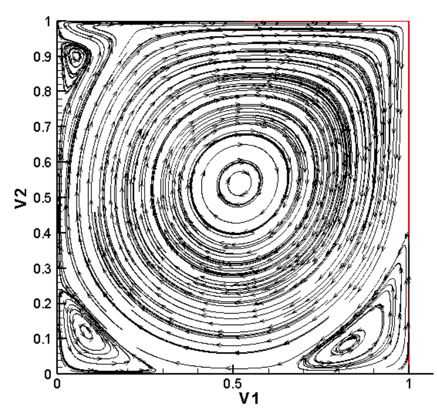
(a)



(b)



(c)



(d)

Streamlines at a) Re=400 b) Re=1000 c) Re=1500 and d) Re =3200