INDIAN INSTITUTE OF TECHNOLOGY, GUWAHATI

DEPARTMENT OF MECHANICAL ENGINEERING

ME 543 (CFD)

Homework Assignment 2

LID DRIVEN SQUARE CAVITY PROBLEM

PROGRAM: M.TECH AP

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A) C code for given problem

```
#include<stdio.h>
#include<math.h>
int main()
{
                FILE *fp,*U,*V;
                fp=fopen("stream.txt","w");
                U=fopen("uv_velocity.txt","w");
  double
SUM,s,error,wold[129][129],siold[129][129],wnew[129][129],sinew[129][129],u[129][129],v[129][129],s
qrdelx,sqrdely,delx=0.0078125,dely=0.0078125,x;
                int i,j,k,count=0;


                sqrdelx=delx*delx;
                sqrdely=sqrdelx;
                for(j=0;j<129;j++)
                {
                     for(i=0;i<129;i++)
                     {
                                siold[i][j]=0;
                                wold[i][j]=0;
                     }
                }
                for(i=1;i<128;i++)
                {
                wold[i][128]=0-(2*128);
                 }
                for(j=0;j<129;j++)
                {
                     for(i=0;i<129;i++)
                     {
                                sinew[i][j]=siold[i][j];
                                wnew[i][j]=wold[i][j];
                     }
                }
                //update si
do
{
//start :
count++;
```

```
for(k=0;k<10;k++)
{
for(j=1;j<128;j++)
        {
        for(i=1;i<128;i++)
            {
            sinew[i][j]=(sinew[i+1][j]+sinew[i-1][j]+sinew[i][j+1]+sinew[i][j-
1]+(sqrdelx*wnew[i][j]))/4.0;
            }
        }
}
        //update boundary condition
        //**********************************************************************
        for(j=1;j<128;j++)
        {
            wnew[0][j]=(0-(2*sinew[1][j]))/sqrdelx;
            wnew[128][j]=(0-(2*sinew[127][j]))/sqrdelx;
        }
        for(i=1;i<128;i++)
        {
            wnew[i][0]=(0-(2*sinew[i][1]))/sqrdely;
            wnew[i][128]=(0-(2*(sinew[i][127]+dely)))/sqrdely;
        }
        //update vorticity
for(k=0;k<2;k++)
{
for(j=1;j<128;j++)
        {
        for(i=1;i<128;i++)
            {
    wnew[i][j]=(wnew[i+1][j]+wnew[i-1][j]+wnew[i][j+1]+wnew[i][j-1]-(100.0*(wnew[i+1][j]-wnew[i-
1][j])*(sinew[i][j+1]-sinew[i][j-1]))+(100.0*(wnew[i][j+1]-wnew[i][j-1])*(sinew[i+1][j]-sinew[i-1][j])))/4.0;
            }
        }
}
SUM=0;
s=0;
        for(j=0;j<129;j++)
        {
            for(i=0;i<129;i++)
            {
                SUM=SUM+fabs(wnew[i][j]-wold[i][j]);
```

```
                    s=s+fabs(wnew[i][j]);
            }
        }
        error=SUM/s;
        printf("error=%lf\n",error);
            for(j=0;j<129;j++)
        {
            for(i=0;i<129;i++)
            {
                    siold[i][j]=sinew[i][j];
                    wold[i][j]=wnew[i][j];
            }
        }
}
        while(error>0.000001);
        for(j=0;j<129;j++)
        {
            for(i=0;i<129;i++)
            {
             fprintf(fp,"%d\t%d\t%lf\n",i+1,j+1,sinew[i][j]);
            }
        }
        for(j=1;j<128;j++)
        {
            for(i=1;i<128;i++)
            {
             u[i][j]=(sinew[i][j+1]-sinew[i][j-1])/(2*dely);
            v[i][j]=(0-1)*(sinew[i+1][j]-sinew[i-1][j])/(2*delx);
            }
        }
        for(j=0;j<129;j++)
        {
            for(i=0;i<129;i++)
            {
            fprintf(U,"%d\t%d\t%lf\t%lf\n",i+1,j+1,u[i][j],v[i][j]);
            }
         }
 //counting no. of iterations
 printf("\n%d",count);
 fclose(fp);
        return 0;
}
```

B) Comparision of data with Ghia’s data

u-velocity along the vertical line through the geometric centre of the cavity			
i	j	My data	Ghia's data
65	129	1.00000	1.00000
65	126	0.756820	0.75837
65	125	0.682551	0.68439
65	124	0.615529	0.61756
65	123	0.556777	0.55892
65	110	0.288433	0.29093
65	95	0.160382	0.16256
65	80	0.019755	0.02135
65	65	-0.116052	-0.11477
65	59	-0.172379	-0.17119
65	37	-0.324515	-0.32726
65	23	-0.237518	-0.24299
65	14	-0.141689	-0.14612
65	10	-0.099967	-0.10338
65	9	-0.089550	-0.09266
65	8	-0.079070	-0.08186
65	1	0.000000	0.00000

Table 1

v-velocity along the horizontal line through the geometric centre of the cavity			
i	j	My data	Ghia's data
129	65	0.00000	0.00000
125	65	-0.122390	-0.12146
124	65	-0.157657	-0.15663
123	65	-0.193594	-0.19254
122	65	-0.229472	-0.22847
117	65	-0.382543	-0.23827
111	65	-0.447675	-0.44993
104	65	-0.382538	-0.38598
65	65	0.052614	0.05186
31	65	0.298871	0.30174
30	65	0.299111	0.30203
21	65	0.278312	0.28124
13	65	0.227009	0.22965
11	65	0.206652	0.20920
10	65	0.194654	0.19713
9	65	0.181208	0.18360
1	65	0.00000	0.00000

Table 2

C) Plot of the u-velocity and v-velocity along the centre line

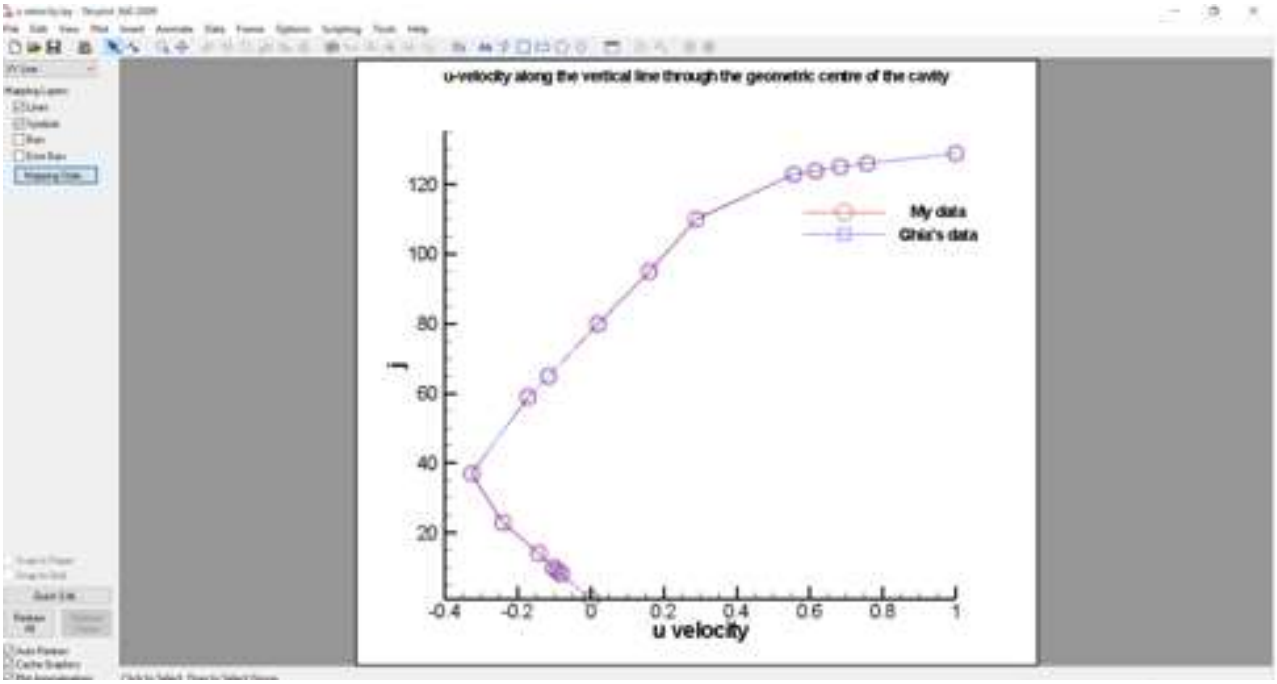

Figure 1

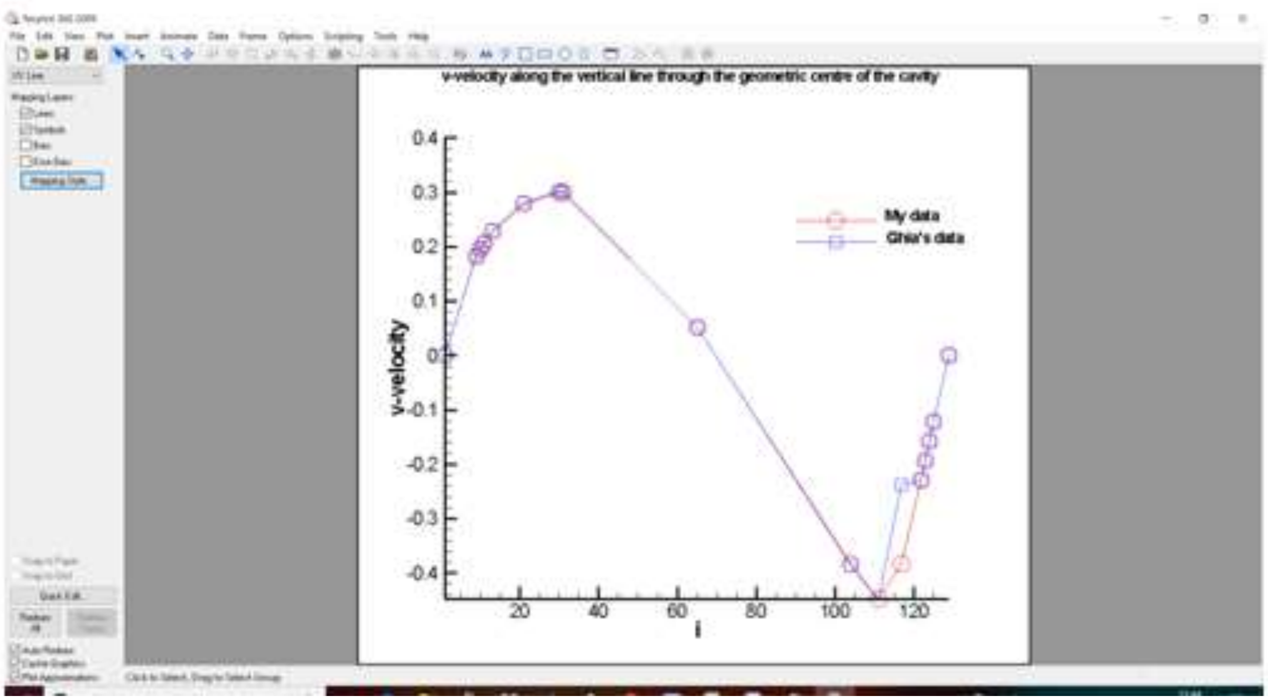

Figure 2

D) Contours of streamlines

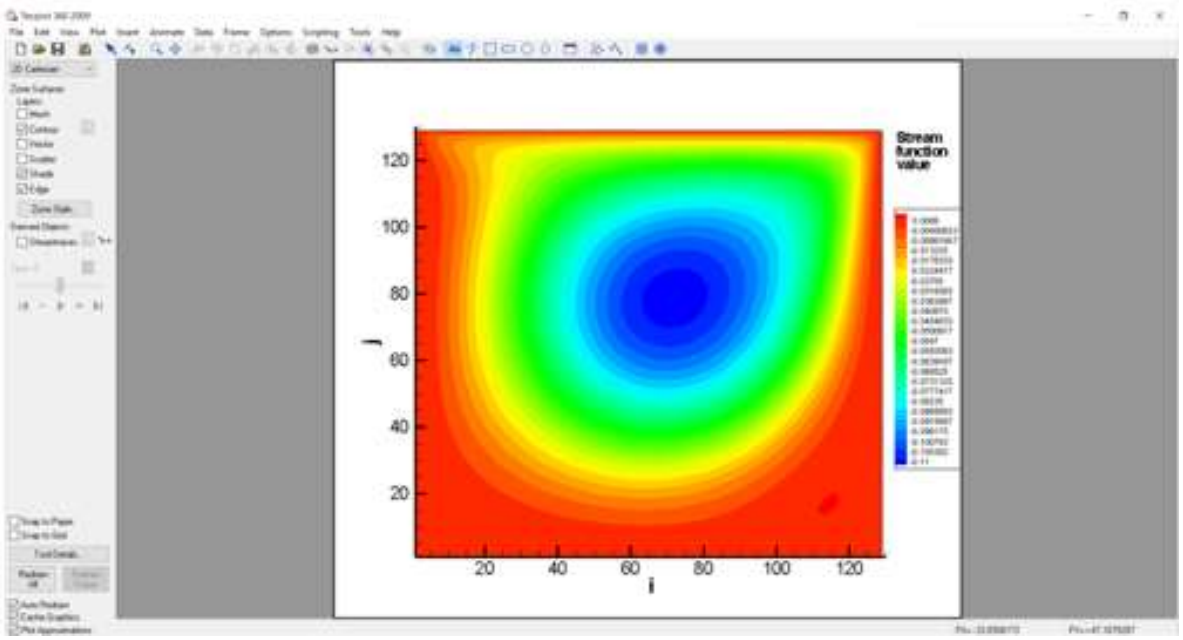

Figure 3

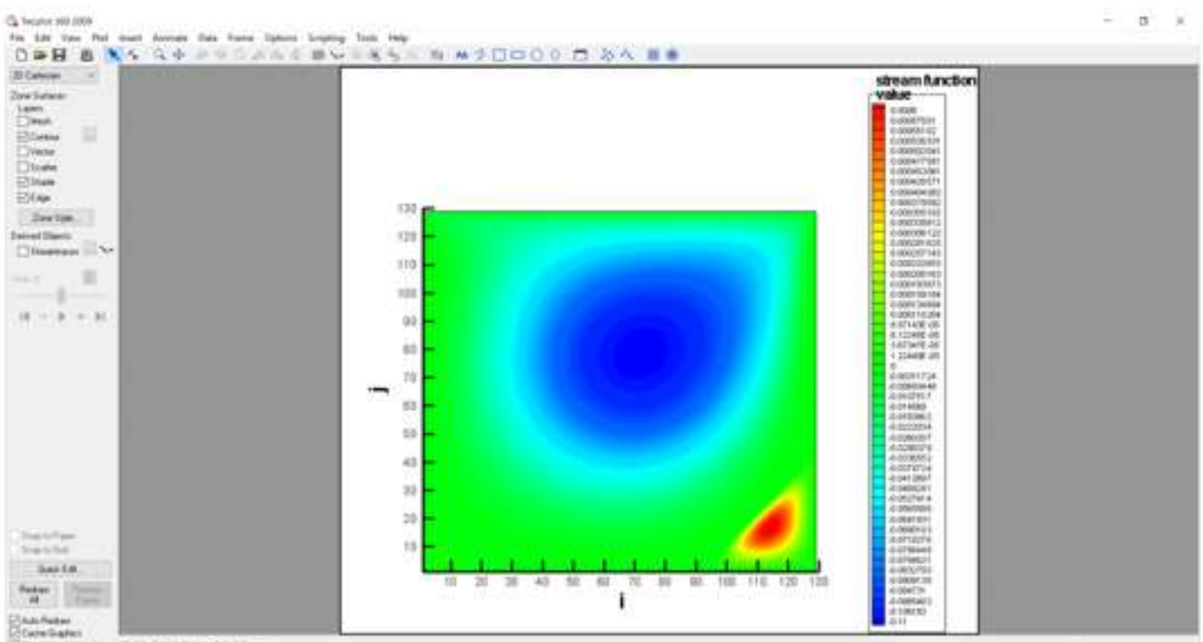

Figure 4

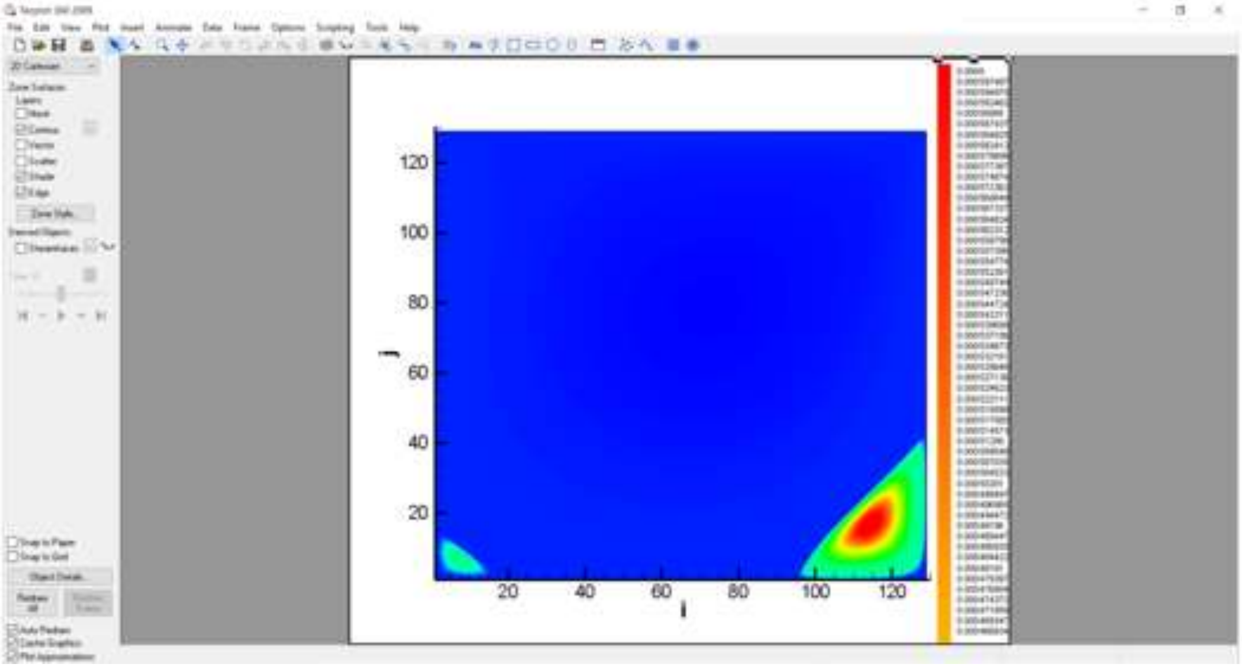

Figure 5

E) Velocity vectors

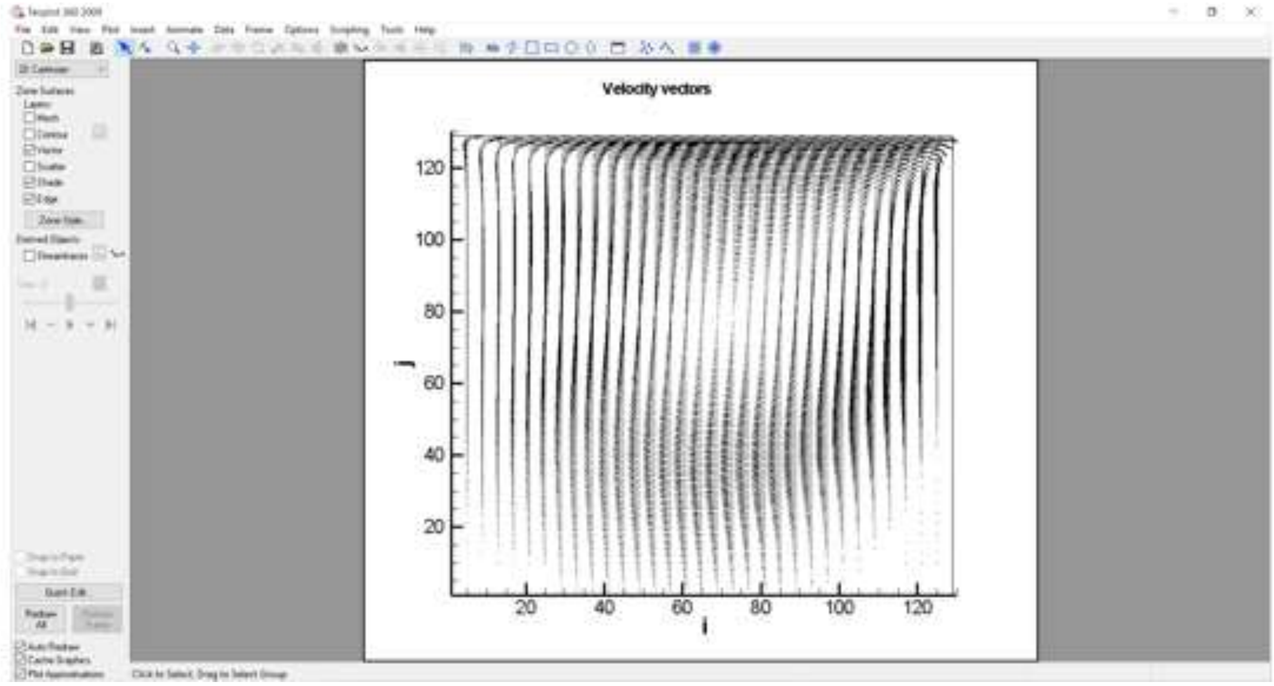

Figure 6

F) Conclusions

1. While comparing the obtained results for the u and v velocities through geometric centres, referring to Tables (1 and 2) and Figures (1 and 2) in can be conclude that the obtained results approximately math with Ghia's data.

2. The contour of constant stream function is shown in Figures (3, 4 and 5) taking various ranges and level to observe details at every grid point which are comparable to Ghia's plots.

3. Velocity at different grid points is plotted in Figure 6, where arrow heads show the direction and length of arrow shows the magnitude of velocity.