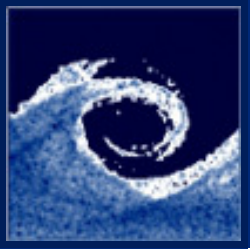
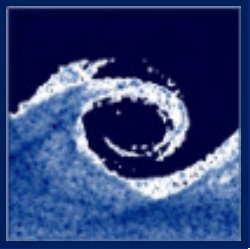


Laboratory tasks I.

1. Create a mesh for the flow simulation two plates
   - Turbulent, incompressible flow (simpleFoam, k-ϵ)
   - Apply Grading the mesh towards the walls
   - Domain size: $L_x = 10m$, $L_y = 1m$, $L_z = 0.1$
   - Cell numbers: $n_x = 100$, $n_y = 40$, $n_z = 1$
   - Grading (last/first): $R_x = 1$, $R_y = 5(0.2)$, $R_z = 1$
2. Set the flow properties, based on
   - $k = 1.5\overline{U}^2 I^2$
   - $\epsilon = C_\mu^{0.75} k^{1.5}/l$
   - Average velocity: $\overline{U} = 1m/s$
   - Turbulence intensity: $I = 0.1$ (10%)
   - Mixing length: $l = 0.1m$
   - Constant of the eddy viscosity: $C_\mu = 0.09$

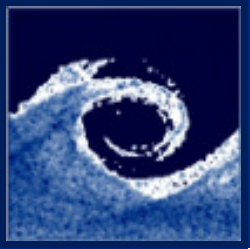


Laboratory tasks II.

3. Create a convergence plot in png format (using the macro)

Listing 1: convergence plot macro

```
1  set terminal postscript eps enhanced color
2  set style line 1 lt 1 lw 1 lc rgb "blue" pt 5 ps 0.2
3  set style line 2 lt 1 lw 1 lc rgb "red" pt 4 ps 0.2
4  set style line 3 lt 1 lw 1 lc rgb "green" pt 7 ps 0.5
5  set style line 4 lt 1 lw 1 lc rgb "orange" pt 2 ps 0.2
6  set style line 5 lt 1 lw 1 lc rgb "black" pt 3 ps 0.2
7  set output 'Convergence.eps'
8  set logscale y
9  set title "Residuals"
10 set ylabel 'Residual'
11 set xlabel 'Iteration'
12 plot "< cat log | grep ' Ux' | cut -d' ' -f9 | tr -d ','" t 'Ux' w l ls 1,\
13      "< cat log | grep ' Uy' | cut -d' ' -f9 | tr -d ','" t 'Uy' w l ls 2,\
14      "< cat log | grep ' eps' | cut -d' ' -f9 | tr -d ','" t 'e' w l ls 3,\
15      "< cat log | grep ' k' | cut -d' ' -f9 | tr -d ','" t 'k' w l ls 4,\
16      "< cat log | grep ' p' | cut -d' ' -f9 | tr -d ','" t 'p' w l ls 5
```

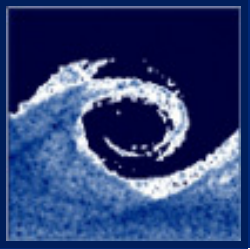


Laboratory tasks III.

4. Sampling the results (system/sampleDict)

Listing 2: sampleDict header

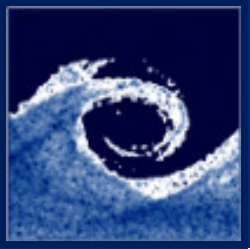
```
1  /*--------------------------------*- C++ -*----------------------------------*\
2  | =========                      |                                           |
3  | \\      /  F ield              | OpenFOAM: The Open Source CFD Toolbox     |
4  |  \\    /   O peration          | Version:  2.2                             |
5  |   \\  /    A nd                 | Web:      http://www.OpenFOAM.org         |
6  |    \\/     M anipulation        |                                           |
7  \*---------------------------------------------------------------------------*/
8
9  FoamFile
10 {
11     version         2.0;
12     format          ascii;
13     class           dictionary;
14     location        system;
15     object          sampleDict;
16 }
17
18 setFormat raw;
19 interpolationScheme cellPoint;
```



Laboratory tasks III.

Listing 3: sampleDict body

```
1  fields( U epsilon k );
2  sets
3  (
4      line00
5      {
6          type         uniform;
7          axis         xyz;
8          start        (0 0 0);
9          end          (0 0 1);
10         nPoints      100;
11     }
12
13     // ...here should be set another line with x = 5
14
15     line10
16     {
17         type         uniform;
18         axis         xyz;
19         start        (10 0 0);
20         end          (10 0 1);
21         nPoints      100;
22     }
23 );
```

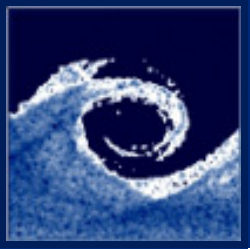


Laboratory tasks IV.

5. Plot the results with gnuplot

Listing 4: gnuplot macro (part 1)

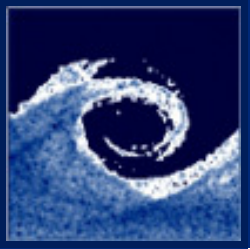
```
1  set terminal postscript eps enhanced color
2  set style line 1 lt 1 lw 1 lc rgb "black" pt 5 ps 0.2
3  set style line 2 lt 1 lw 1 lc rgb "red" pt 4 ps 0.2
4  set style line 3 lt 1 lw 1 lc rgb "green" pt 7 ps 0.5
5  set style line 4 lt 1 lw 1 lc rgb "blue" pt 2 ps 0.2
6  set style line 5 lt 1 lw 1 lc rgb "orange" pt 3 ps 0.2
7
8  set pointsize 0.8
9  set key top right
10 set key spacing 1.2
11 set output "Profiles.eps"
```



Laboratory tasks IV.

Listing 5: gnuplot macro (part 2)

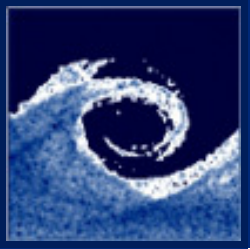
```
1  NX=2;
2  NY=2;
3  DX=0.18;
4  DY=0.18;
5  SX=0.5;
6  SY=0.6;
7  SXT=SX*NX+DX*(NX+0.5);
8  SYT=SY*NY+DY*(NY+0.5);
9
10 set bmargin 0; set tmargin 0; set lmargin 0; set rmargin 0
11 set border ls 1
12 set size SXT, SYT
13 set multiplot
14 set size SX, SY
```



Laboratory tasks IV.

Listing 6: gnuplot macro (part 3)

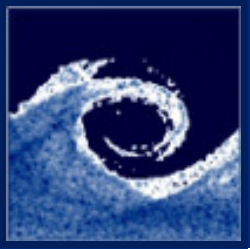
```
1  NXC=1;
2  NYC=1;
3  set xlabel "U [ms^{-2}]"
4  set ylabel "y [m]"
5  set xrange [0 : 2]
6  set yrange [ 0 : 1]
7  set key left top
8  set origin (NXC-1)*SX + NXC*DX, SYT - (NYC*SY + NYC*DY)
9  set title "x-velocity"
10 plot "postProcessing/sets/300/line00_U.xy" u 4:2 t "x=0" w l ls 2, \
11      "postProcessing/sets/300/line05_U.xy" u 4:2 t "x=5" w l ls 3, \
12      "postProcessing/sets/300/line10_U.xy" u 4:2 t "x=10" w l ls 4
```



Laboratory tasks IV.

Listing 7: gnuplot macro (part 4)

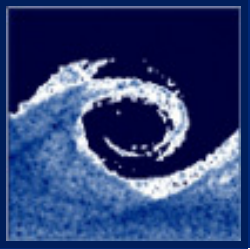
```
1  NXC=2;
2  NYC=1;
3  set xlabel "V [ms^{-2}]"
4  set ylabel "y [m]"
5  set xrange [-0.01 : 0.01]
6  set yrange [ 0 : 1]
7  set key left top
8  set origin (NXC-1)*SX + NXC*DX, SYT - (NYC*SY + NYC*DY)
9  set title "y-velocity"
10 plot "postProcessing/sets/300/line00_U.xy" u 5:2 t "x=0" w l ls 2, \
11      "postProcessing/sets/300/line05_U.xy" u 5:2 t "x=5" w l ls 3, \
12      "postProcessing/sets/300/line10_U.xy" u 5:2 t "x=10" w l ls 4
```



Laboratory tasks IV.

Listing 8: gnuplot macro (part 5)

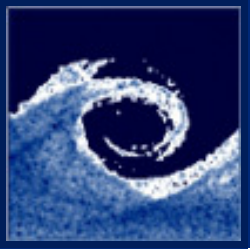
```
1  NXC=1;
2  NYC=2;
3  set logscale x
4  set key right top
5  set xlabel "k [m^{2}s^{-2}]"
6  set ylabel "z [m]"
7  set xrange [0.0001 : 0.1]
8  set yrange [ 0 : 1]
9  set origin (NXC-1)*SX + NXC*DX, SYT - (NYC*SY + NYC*DY)
10 set title "turbulent kinetic energy"
11 plot "postProcessing/sets/300/line00_epsilon_k.xy" u 4:2 t "x=0" w l ls 2, \
12      "postProcessing/sets/300/line05_epsilon_k.xy" u 4:2 t "x=5" w l ls 3, \
13      "postProcessing/sets/300/line10_epsilon_k.xy" u 4:2 t "x=10" w l ls 4
```



Laboratory tasks IV.

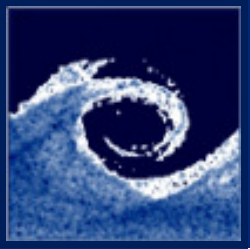
Listing 9: gnuplot macro (part 6)

```
1  NXC=2;
2  NYC=2;
3  set logscale x
4  set xlabel "{/Symbol e} [m^{2}s^{-3}]"
5  set ylabel "z [m]"
6  set xrange [ 0.001 : 0.1]
7  set yrange [ 0 : 1]
8  set origin (NXC-1)*SX + NXC*DX, SYT - (NYC*SY + NYC*DY)
9  set title "turbulent dissipation rate"
10 plot "postProcessing/sets/300/line00_epsilon_k.xy" u 5:2 t "x=0" w l ls 2, \
11      "postProcessing/sets/300/line05_epsilon_k.xy" u 5:2 t "x=5" w l ls 3, \
12      "postProcessing/sets/300/line10_epsilon_k.xy" u 5:2 t "x=10" w l ls 4
```



Assignments

1. Show the plots to the lecturers (quickest students earn bonus points).
2. Convert the plots to png format (quickest students earn bonus points).
3. Which parameter should be modified for plotting 3x3 figure array?



Homework

1. Practice gnuplot through examples