

Laboratory tasks I.

Programming

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- 1 Create a mesh for the flow simulation between plates
 - Turbulent, incompressible flow (simpleFoam, $k-\epsilon$)
 - 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
 - $k = 1.5\bar{U}^2 I^2$
 - $\epsilon = C_\mu^{0.75} k^{1.5} / l$
 - Average velocity: $\bar{U} = 1m/s$
 - Turbulence intensity: $I = 0.1$ (10%)
 - Mixing length: $l = 0.1m$
 - Constant of the eddy viscosity: $C_\mu = 0.09$

Laboratory tasks II.

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- 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.

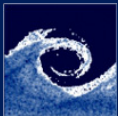
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4 Sampling the results (system/sampleDict)

Listing 2: sampleDict header

```
1 /*-----* C++ *-----*/
2 |-----|
3 | \ \ / / F i e l d | OpenFOAM: The Open Source CFD Toolbox |
4 | \ \ / / O p e r a t i o n | Version: 2.2 |
5 | \ \ / / A n d | Web: http://www.OpenFOAM.org |
6 | \ \ / / M a n i p u l a t i o n | |
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;
```



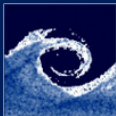
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Listing 3: sampleDict body

```
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.

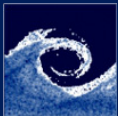
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5 Plot the results with gnuplot

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"
```



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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
```

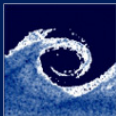
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Listing 6: gnuplot macro (part 3)

```
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
```



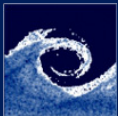
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Listing 7: gnuplot macro (part 4)

```
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
```

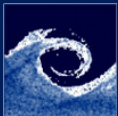
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Listing 8: gnuplot macro (part 5)

```
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
```



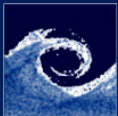
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Listing 9: gnuplot macro (part 6)

```
1 NXC=2;
2 NYC=2;
3 set logscale x
4 set xlabel "{/Symbol e} [m2s-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
```

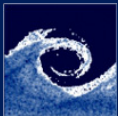


Assignments

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- 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

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- 1 Practice gnuplot through [examples](#)