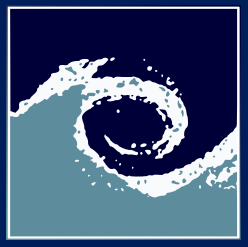


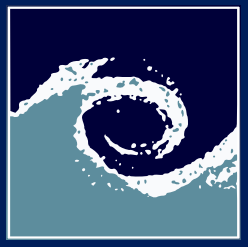


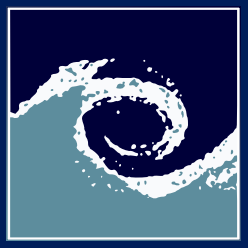
# Laboratory Session 8

## Open-Source CFD Course 2021

Miklós BALOGH and Josh DAVIDSON

2021

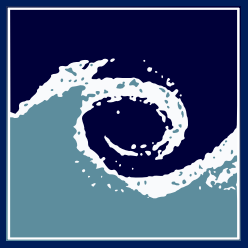




# Floating object tutorial – 2D



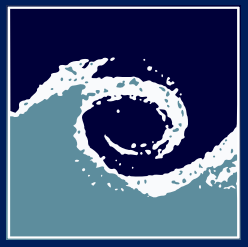
- Recall the floating object tutorial from last week's lab
- Suppose we want to investigate the effect of certain parameters on the result
  - The mesh resolution around the floating object and the free surface interface
  - Whether waves radiation from the floating object reflect off the side walls and influence the floating object motion
- The computational requirements/runtimes, of the numerous simulations required to investigate the effect of these parameters on the results, can be reduced by performing a "2D" simulation, where the domain is only 1 cell thick.



# Tasks



1. Make a copy of last week's free decay floatingObject case setup, run ./Allclean and then modify the case to make a 2D simulation
   - 1.1 *system/blockMeshDict*:
     - Change the width of the tank from 1m to 0.01m :*(Lines 23,24,27,28)*
     - Set the number of cells in the $y$-direction to be 1 :*(Line 33)*
     - Change the boundary condition on the front and back walls to *empty* :*(Lines 42-60)*
   - 1.2 *constant/topoSetDict*
     - Change the $y$ position of the floating object :*(Line 24)*
   - 1.3 *constant/dynamicMeshDict*
     - Change the width of the floating object :*(Line 43)*
   - 1.4 *0/**
     - Change the boundary conditions for the front and back walls to *empty* :*(Line 33)*



# 1.1 *system/blockMeshDict*

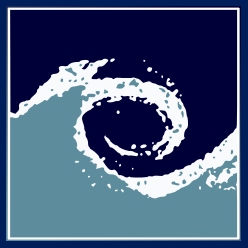


## Original

```
19 vertices
20 (
21     (0 0 0)
22     (1 0 0)
23     (1 1 0)
24     (0 1 0)
25     (0 0 1)
26     (1 0 1)
27     (1 1 1)
28     (0 1 1)
29 );
30
31 blocks
32 (
33     hex (0 1 2 3 4 5 6 7) (20 20 30) simpleGrading (1 1 1)
34 );
35
36 edges
37 (
38 );
39
40 boundary
41 (
42     stationaryWalls
43     {
44         type wall;
45         faces
46         (
47             (0 3 2 1)
48             (2 6 5 1)
49             (1 5 4 0)
50             (3 7 6 2)
51             (0 4 7 3)
52         );
53     }
54     atmosphere
55     {
```

## Modified

```
19 vertices
20 (
21     (0 0 0)
22     (1 0 0)
23     (1 0.01 0)
24     (0 0.01 0)
25     (0 0 1)
26     (1 0 1)
27     (1 0.01 1)
28     (0 0.01 1)
29 );
30
31 blocks
32 (
33     hex (0 1 2 3 4 5 6 7) (20 1 30) simpleGrading (1 1 1)
34 );
35
36 edges
37 (
38 );
39
40 boundary
41 (
42     frontAndBack
43     {
44         type empty;
45         faces
46         (
47             (1 5 4 0)
48             (3 7 6 2)
49         );
50     }
51     stationaryWalls
52     {
53         type wall;
54         faces
55         (
56             (0 3 2 1)
57             (2 6 5 1)
58             (0 4 7 3)
59         );
60     }
61     atmosphere
62     {
```



# 1.2 *system/topoSetDict*

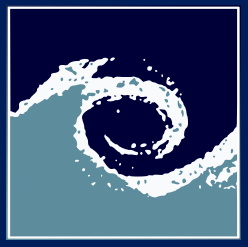


## Original

```
18 actions
19 (
20     {
21         name    c0;
22         type    cellSet;
23         action  new;
24         source  boxToCell;
25         sourceInfo
26         {
27             box (0.35 0.35 0.1) (0.65 0.55 0.6);
28         }
29     }
```

## Modified

```
18 actions
19 (
20     {
21         name    c0;
22         type    cellSet;
23         action  new;
24         source  boxToCell;
25         sourceInfo
26         {
27             box (0.35 0 0.1) (0.65 0.01 0.6);
28         }
29     }
```



# 1.3 *constant/dynamicMeshDict*

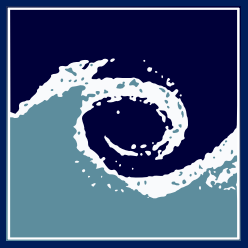


## Original

```
27  solver
28  {
29      type Newmark;
30  }
31
32  accelerationRelaxation 0.7;
33
34  bodies
35  {
36      floatingObject
37      {
38          type            cuboid;
39          parent          root;
40
41          // Cuboid dimensions
42          Lx              0.3;
43          Ly              0.2;
44          Lz              0.5;
45
46          // Density of the cuboid
47          rho             800;
48
49          // Cuboid mass
50          mass            #calc "$rho*$Lx*$Ly*$Lz";
```

## Modified

```
27  solver
28  {
29      type Newmark;
30  }
31
32  accelerationRelaxation 0.7;
33
34  bodies
35  {
36      floatingObject
37      {
38          type            cuboid;
39          parent          root;
40
41          // Cuboid dimensions
42          Lx              0.3;
43          Ly              0.01;
44          Lz              0.5;
45
46          // Density of the cuboid
47          rho             800;
48
49          // Cuboid mass
50          mass            #calc "$rho*$Lx*$Ly*$Lz";
```



# 1.4 *0/**

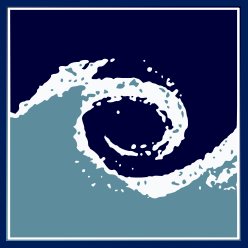


Add the boundary conditions for *frontAndBack* to all of the variables in the *0* folder

```
frontAndBack
{
    type            empty;
}
```

You can either do this one-by-one for each file, or use the following command to do every file automatically at once:

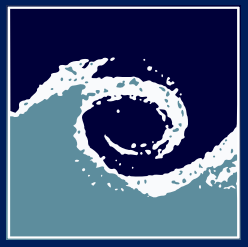
```
OpenFOAM/Lab_Week8/floatingObject2$ cd 0
OpenFOAM/Lab_Week8/floatingObject2/0$ sed -i s/"stationaryWalls"/"frontAndBack{ type empty; } stationaryWalls"/g *
```



# Results

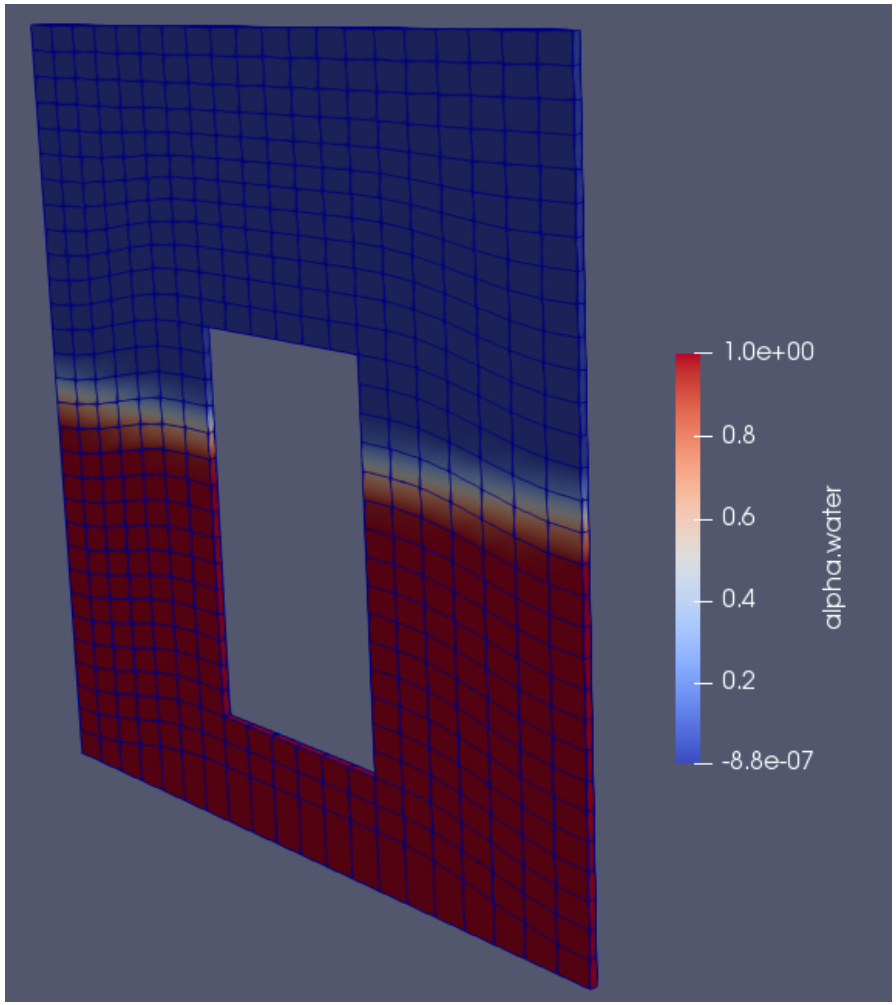


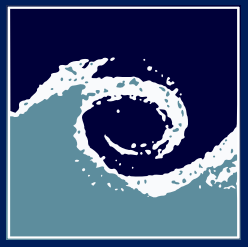
- 2.1 **Bonus mark** - How much faster does the 2D simulation run than the 3D simulation in last week's lab session?
- 2.2 **Bonus mark** - Reproduce the figures in the next two slides



# alpha.water at time = 5s

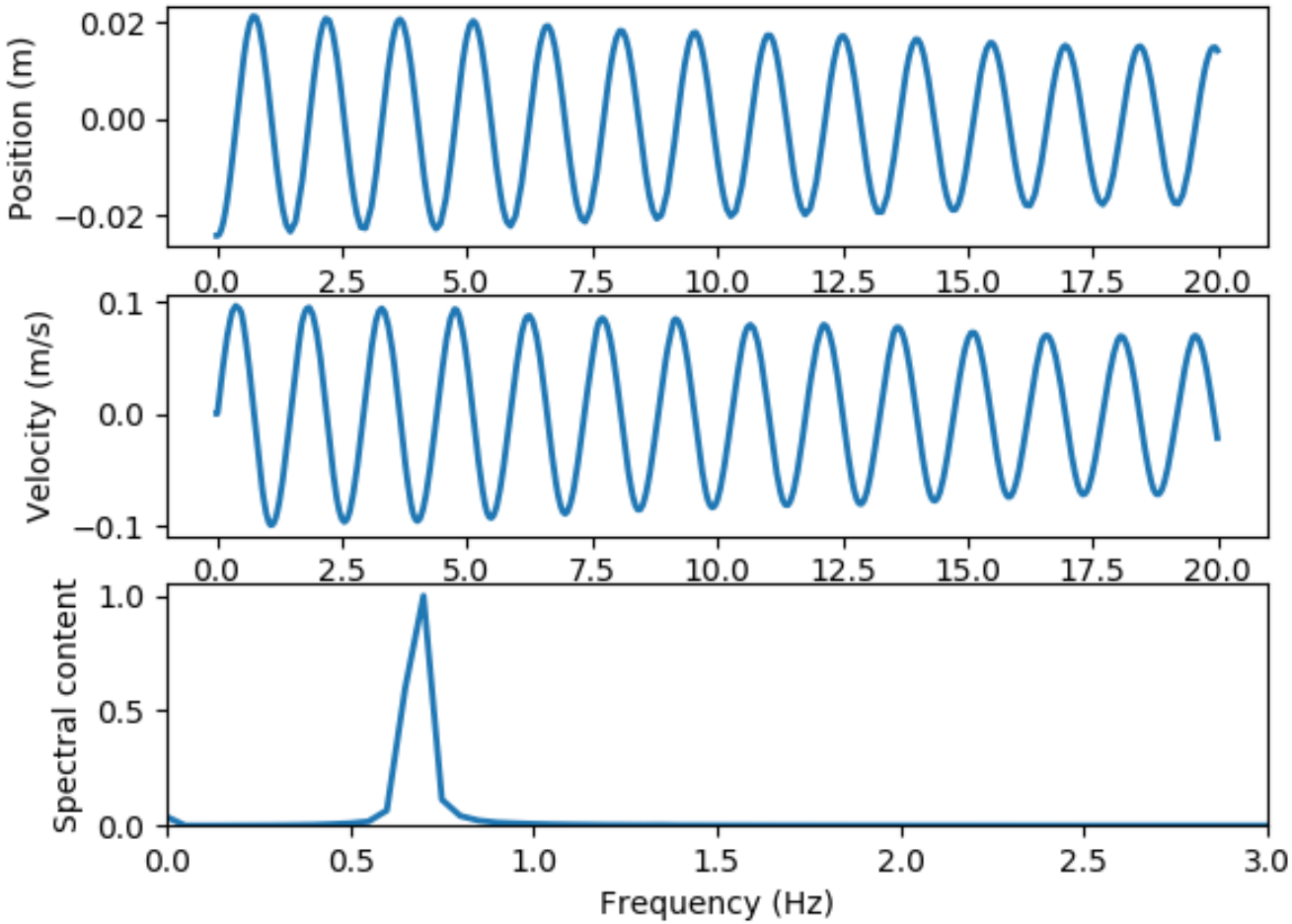


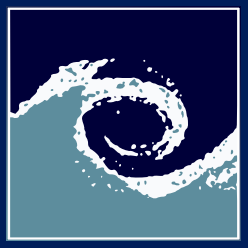




# Free decay results



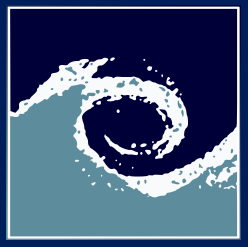




# Tasks



2. Modify the tank geometry - *system/blockMeshDict*
   - Increase the width of the tank to 4m :*(Lines 21-28)*
   - Increase the depth of the tank to 2m :*(Lines 21-24)*
   - Double the mesh density :*(Line 33)*
3. Increase the mesh resolution around the body and the free surface interface
   - 3.1 *system/topoSetDict*
     - Rename *topoSetDict* to *topoSetDict.1*
     - Make 3 more copies of *topoSetDict.1*, rename them to *topoSetDict.2*, *topoSetDict.3* and *topoSetDict.4* and then modify them :*(Line 27)*
   - 3.2 *system/refineMeshDict*
     - Make the *refineMeshDict* file
   - 3.3 *./Allrun*
     - Modify the *Allrun* file



# 2 system/blockMeshDict

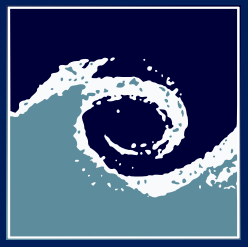


## Original

```
19 vertices
20 (
21     (0 0 0)
22     (1 0 0)
23     (1 0.01 0)
24     (0 0.01 0)
25     (0 0 1)
26     (1 0 1)
27     (1 0.01 1)
28     (0 0.01 1)
29 );
30
31 blocks
32 (
33     hex (0 1 2 3 4 5 6 7) (20 1 30) simpleGrading (1 1 1)
34 );
35
36 edges
37 (
38 );
39
```

## Modified

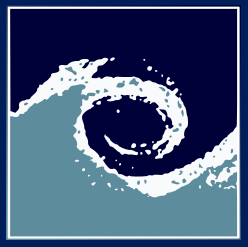
```
19 vertices
20 (
21     (-1.5 0 -1)
22     (2.5 0 -1)
23     (2.5 0.01 -1)
24     (-1.5 0.01 -1)
25     (-1.5 0 1)
26     (2.5 0 1)
27     (2.5 0.01 1)
28     (-1.5 0.01 1)
29 );
30
31 blocks
32 (
33     hex (0 1 2 3 4 5 6 7) (160 1 120) simpleGrading (1 1 1)
34 );
35
36 edges
37 (
38 );
39
```



# 3.1 *system/topoSetDict.1*



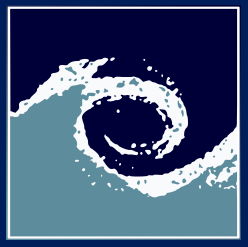
```
18 actions
19 (
20     {
21         name    c0;
22         type    cellSet;
23         action  new;
24         source  boxToCell;
25         sourceInfo
26         {
27             box (0.35 0 0.1) (0.65 0.01 0.6);
28         }
29     }
30
31     {
32         name    c0;
33         type    cellSet;
34         action  invert;
35     }
36 );
```



# 3.1 *system/topoSetDict.2*



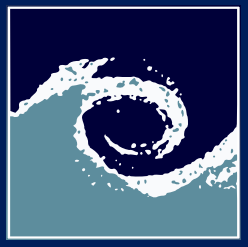
```
 8 FoamFile
 9 {
10     version     2.0;
11     format      ascii;
12     class       dictionary;
13     object      topoSetDict;
14 }
15 // * * * * * * * * * * * * * * * * * * * * * * * *
16
17 actions
18 (
19     {
20         name    c0;
21         type    cellSet;
22         action  new;
23         source  boxToCell;
24         box     (0.25 0 0) (0.75 0.01 0.7);
25     }
26
27     {
28         name    c0;
29         type    cellSet;
30         action  invert;
31     }
32 );
```



# 3.1 *system/topoSetDict.3*



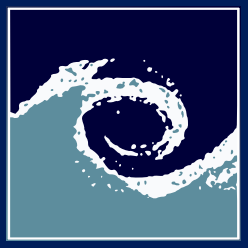
```
 8 FoamFile
 9 {
10     version     2.0;
11     format      ascii;
12     class       dictionary;
13     object      topoSetDict;
14 }
15 // * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
16
17 actions
18 (
19     {
20         name    c0;
21         type    cellSet;
22         action  new;
23         source  boxToCell;
24         box     (-100 -100 0.45) (0.25 100 0.6);
25     }
26
27     {
28         name    c0;
29         type    cellSet;
30         action  invert;
31     }
32 );
```



# 3.1 *system/topoSetDict.4*



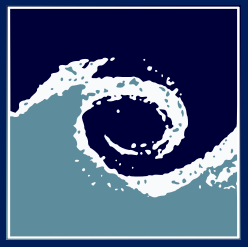
```
 7 \* --------------------------------------------
 8 FoamFile
 9 {
10     version     2.0;
11     format      ascii;
12     class       dictionary;
13     object      topoSetDict;
14 }
15 // * * * * * * * * * * * * * * * * * * * * * * * * *
16
17 actions
18 (
19     {
20         name    c0;
21         type    cellSet;
22         action  new;
23         source  boxToCell;
24         box     (0.75 -100 0.45) (100 100 0.6);
25     }
26
27     {
28         name    c0;
29         type    cellSet;
30         action  invert;
31     }
32 );
33
```



# 3.2 *system/refineMeshDict*



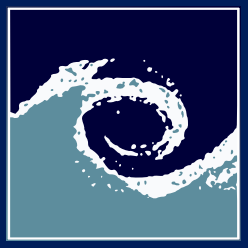
```
 8 FoamFile
 9 {
10     version     2.0;
11     format      ascii;
12     class       dictionary;
13     location    "system";
14     object      refineMeshDict;
15 }
16 // * * * * * * * * * * * * * * * * * *
17
18 set             c0;
19
20 coordinateSystem global;
21
22 globalCoeffs
23 {
24     tan1            (0 0 1);
25     tan2            (1 0 0);
26 }
27
28
29 directions
30 (
31     tan1
32     tan2
33 );
34
35 useHexTopology  no;
36
37 geometricCut    yes;
38
39 writeMesh       no;
```



# 3.3 ./Allrun



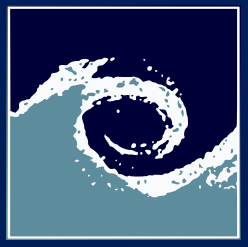
```
1 #!/bin/sh
2 cd ${0%/*} || exit 1    # Run from this directory
3
4 # Source tutorial run functions
5 . $WM_PROJECT_DIR/bin/tools/RunFunctions
6
7 # Set application name
8 application=$(getApplication)
9
10 #Create the background mesh for tank and floating object
11 runApplication blockMesh
12 cp system/topoSetDict.1 system/topoSetDict
13 topoSet > log.topoSet1
14 runApplication subsetMesh -overwrite c0 -patch floatingObject -noFields
15 #Refine the mesh around the body and the free surface interface
16 cp system/topoSetDict.2 system/topoSetDict
17 topoSet > log.topoSet2
18 refineMesh -overwrite > log.refineMesh1
19 cp system/topoSetDict.3 system/topoSetDict
20 topoSet > log.topoSet3
21 refineMesh -overwrite > log.refineMesh2
22 cp system/topoSetDict.4 system/topoSetDict
23 topoSet > log.topoSet4
24 refineMesh -overwrite > log.refineMesh3
25 #Set the fields and run the simulation
26 runApplication setFields
27 runApplication $application
```



# Results

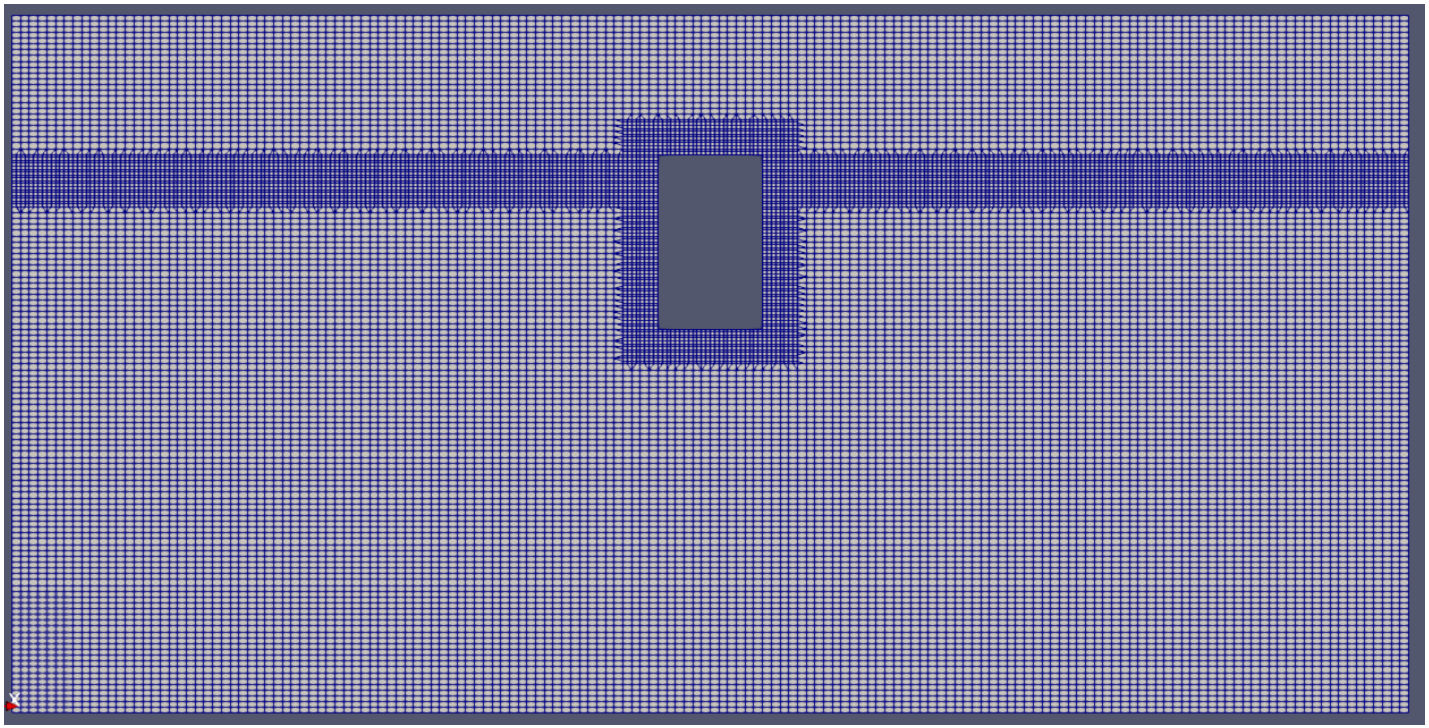


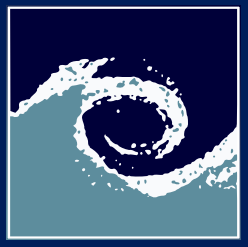
- **Bonus mark** - How many cells are used in this simulation?
- **Bonus mark** - Reproduce the figures in the next two slides



# Mesh at time = 0s

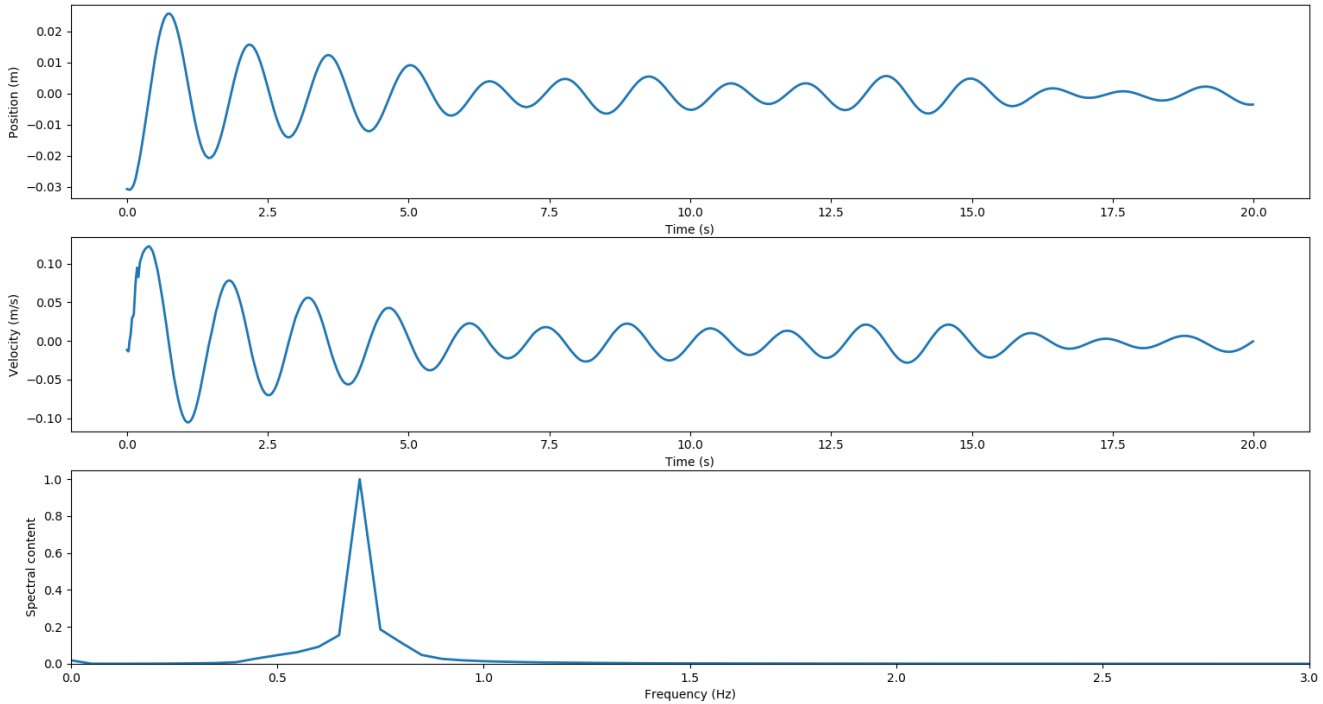


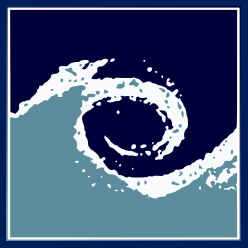




# Free decay results







# Assignments



**3 Bonus marks** - Using the files and boundary conditions from the tutorial *multiphase/interFoam/laminar/waves/stokesI*, further modify the *floatingObject* case from this lab session, to drive the motion of the floating object with waves created from the boundary