Open Source CFD course **Mid-term examination** **Date: 1st April 2015**	**Name: _________________________** **NEPTUN: _________________________** **Signature: _________________________**

1. Perform a transient 2D incompressible simulation of a laminar room temperature air flow inside a T-junction with one inlet and two outlets using Newtonian fluid model! Geometry is shown in Figure 1, but the T-junction is from the USA, so dimensions are in inches (1 inch = 2.54 cm). Construct a mesh of 4 blocks in blockMesh. The number of cells (as shown in Figure 1) should be 20x20, 20x20, 30x20 and 20x30. The 20x20 blocks should have uniform cell size, while the 30x20 and the 20x30 blocks should have a “smooth grading”: cell expansion ratio should be exactly 1 where different blocks connect. Inlet velocity U_{in} should be set to 0.1 m/s and the two outlets should be set to the same static pressure. Assign different patch names to the two outlet boundaries!

Note: The total length can be calculated as $L_{total} = l_1 (q^n - 1)/(q – 1)$, where l_1 is the length of the first interval, q is the cell expansion ratio and n is the number of the intervals for the given total length. This equation can be solved iteratively for q. Important to see, that the last-first ratio for simple-grading is calculated as $r_{lf} = l_n/l_1 = q^{n-1}$. Viscosity of room temperature air is 1.5e-5 m^2/s.

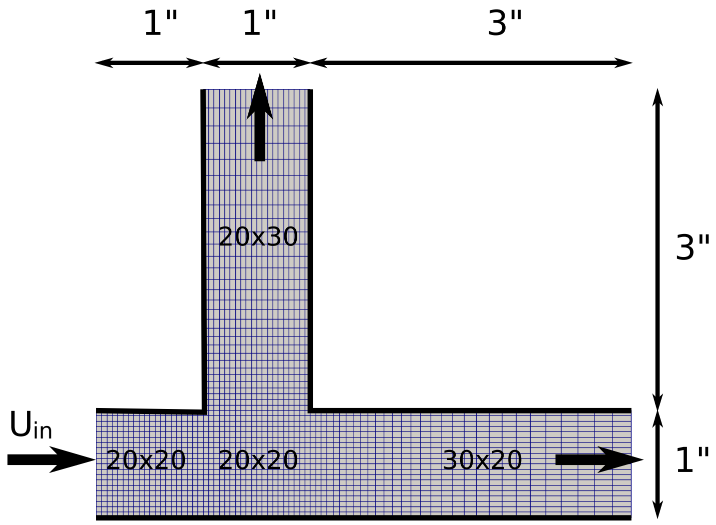

Figure 1. The geometry of the domain

Visualize results in Paraview and gnuplot and save images in **PNG file format**:

a.) Paraview image showing the mesh

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with correct sizes and cell numbers

__ / 10 p

with correct gradings

__ / 10 p

b.) Paraview image showing the velocity magnitude distribution for converged solution

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c.) Paraview image showing the Courant number distribution for converged solution

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d.) Paraview image showing all the separations in the flow using streamlines for converged solution

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e.) gnuplot image showing the time-evolution (convergence) of the average flow speed of 2 outlets

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Show results to teachers when you are ready with these tasks!

Signature of teacher: __________

2. Which linux command can be used for counting the number of lines in a text file?

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3. What is the symbolic form of the following equation?

```
solve
(
    fvm::ddt(c)
  - ((D*a) & fvc::grad(c))
  - fvm::laplacian(D, c)
);
```

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4. In OpenFOAM, what dimension vector corresponds to Watt (J/s)?

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5. Which OpenFOAM utility can be used to determine non-orthogonality and skewness?

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6. List the different viscosity models implemented in OpenFoam for incompressible cases!

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7. Calculate the number of cells and the simpleGrading value for blockMeshDict in a 1 m sized block with (approximately) 1 mm first cell size and 1.05 cell expansion ratio!

Number of cells: simpleGrading:

___ / 10 p

8. How can you estimate the maximum Courant number before starting a simulation?

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9. What does valueFraction=0 and valueFraction=1 mean in a mixed boundary condition?

___ / 5 p

10. How can you obtain the symmetric and antisymmetric part of a tensor **T** in OpenFOAM code?

___ / 5 p

Total: ___ / 100 p

Signature of teacher: ___________