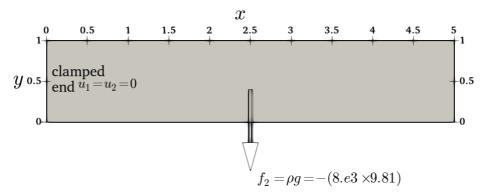
# **Linear Elasticity Tutorial 1:**

To showcase the usage of Linear elasticity, we shall discuss here an example of a 2D bar, which bends under its own load. The bar  $5\times 1~\text{m}^2$  in area is made up of material with  $~\rho=8\times 10^3$ ,  $E=200\times 10^9$ , and  $\nu=0.3$ .



### **Step 1: Preprocessing**

First step in a PSD simulation is PSD preprocessing, at this step you tell PSD what kind of physics, boundary conditions, approximations, mesh, etc are you expecting to solve.

In the terminal cd to the folder \home\PSD-tutorials\linear-elasticity . Launch PSD\_PreProcess from the terminal, to do so run the following command.

```
PSD_PreProcess -dimension 2 -bodyforceconditions 1 -dirichletconditions 1 - postprocess u
```

After the PSD\_PreProcess runs successfully you should see many .edp files in your current folder.

What do the arguments mean? -dimension 2 means it is a 2D simulation, -bodyforceconditions

1 with body force; -dirichlet conditions 1 says we have one Dirichlet border; and postprocess u means we would like to have ParaView post processing files.

At this stage the input properties  $E, \nu$  can be mentioned in <code>ControlParameters.edp</code>, use <code>E = 200.e9</code>, and <code>nu = 0.3</code>; . The volumetric body force condition is mentioned in the same file via variable <code>Fbc0Fy -78480.0</code>, i.e  $(\rho*g=8.e3*(-9.81)=-78480.0)$ . One can also provide the mesh to be used in <code>ControlParameters.edp</code>, via <code>ThName = "../Meshes/2D/bar.msh"</code> (note that mesh can also be provided in the next step) . In addition variable <code>Fbc00n 1</code> has to be provided in order to indicate the volume (region) for which the body force is acting, here <code>1</code> is the integer volume tag of the mesh. Dirichlet boundary conditions are also provided in <code>ControlParameters.edp</code>. To provide the clamped boundary condition the variables <code>Dbc00n 2</code>, <code>Dbc0Ux 0.</code>, and <code>Dbc0Uy 0.</code> are used, which means for Dirichlet border <code>2</code> (<code>Dbc00n 2</code>) where <code>2</code> is the clamped border label of the mesh <code>Dirichlet constrain</code> is applied and <code>Dbc0Ux 0.</code>, <code>Dbc0Uy 0</code> i.e., the clamped end condition ( $u_x = u_y = 0$ ).

### Step 2: Solving

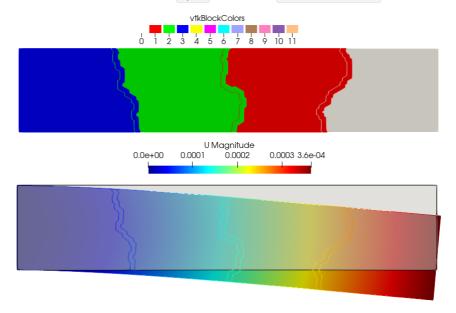
As PSD is a parallel solver, let us use 4 cores to solve the 2D bar case. To do so enter the following command:

```
PSD_Solve -np 4 Main.edp -mesh ./../Meshes/2D/bar.msh -v 0
```

Here -np 4 denote the argument used to enter the number of parallel processes (MPI processes) used while solving. -mesh ./../Meshes/2D/bar.msh is used to provide the mesh file to the solver.
-v 0 denotes the verbosity level on screen. PSD\_Solve is a wrapper around FreeFem++ or FreeFem++-mpi. Note that if your problem is large use more cores. PSD has been tested upto 13,000 parallel processes and problem sizes with billions of unknowns, surely you will now need that many for the 2D bar problem.

#### **Step 3: Postprocessing**

PSD allows postprocessing of results in ParaView. After the step 2 mentioned above finishes. Launch ParaView and have a look at the .pvd file in the VTUs\_DATE\_TIME folder.



You are all done with your 2D linear-elasticty simulation.

## 2D bar is ok, but what about 3D?

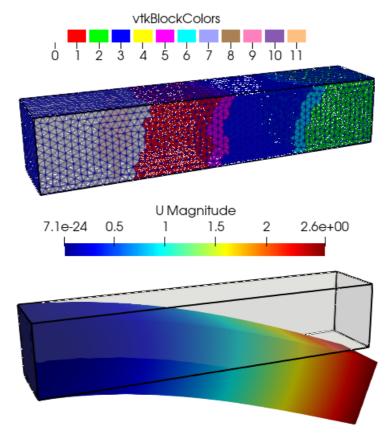
3D follows the same logic as 2D, in the preprocessing step

```
PSD_PreProcess -dimension 3 -bodyforceconditions 1 -dirichletconditions 1
```

note that all what has changed -dimension 3 instead of -dimension 2

Solving step remains exactly the same with -mesh flag now pointing towards the 3D mesh.

```
PSD_Solve -np 4 Main.edp -mesh ./../Meshes/3D/bar.msh -v 0
```



# What else should you try

- Optionally try using -fastmethod flag with PSD\_PreProcess for producing optimized codes, you are encouraged to have a look at ControlParameters.edp file produced with -fastmethod flag and without -fastmethod flag.
- Add -sequential flag to PSD\_PreProcess for sequential solver, but remember to use PSD\_Solve\_Seq instead of PSD\_Solve and no -np flag.

```
PSD_PreProcess -dimension 2 -sequential -bodyforceconditions 1 -
dirichletconditions 2 -postprocess u

PSD_Solve_Seq -np 4 Main.edp -mesh ./../Meshes/3D/bar.msh -v 0
```

- You are encouraged to time your the PSD solver and see if you have considerable gains when using more processes in parallel PSD or when comparing a a sequential solver with a parallel one. To time the solver use -timelog flag during PSD\_PreProcess.
- You are encouraged to use more complex meshes for this same problem, but do not forget to update the ControlParameters.edp file.