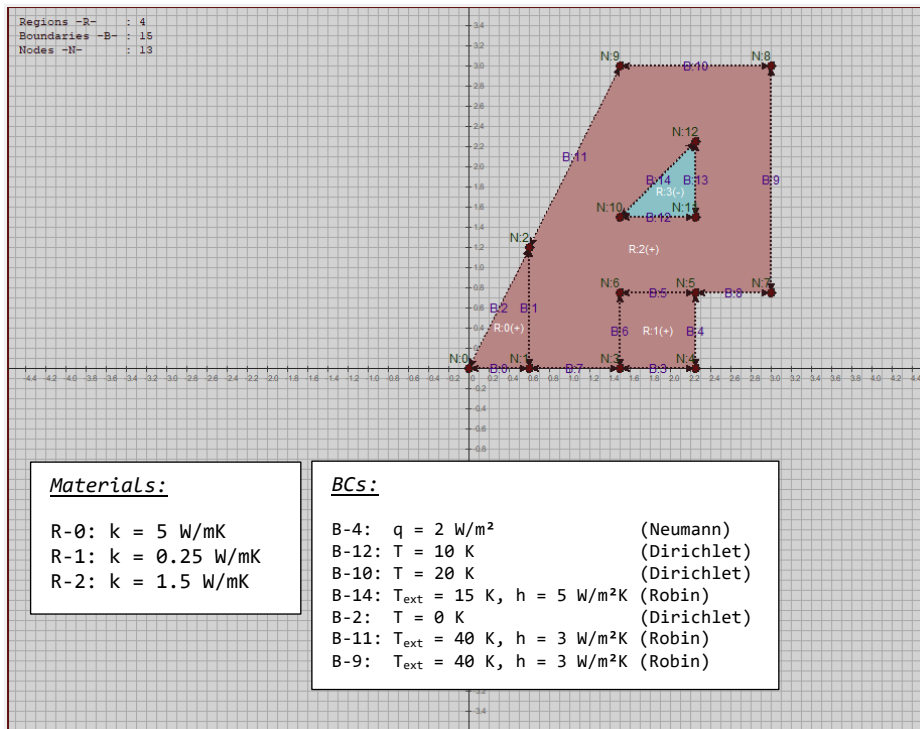# Verification *Tiny*FEM

Version: 1.0.0
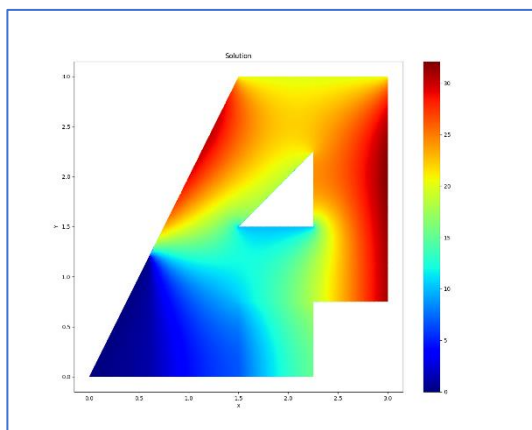
Authors: Elias Perras, Marius Mellmann

Verification with Professional FEM framework.
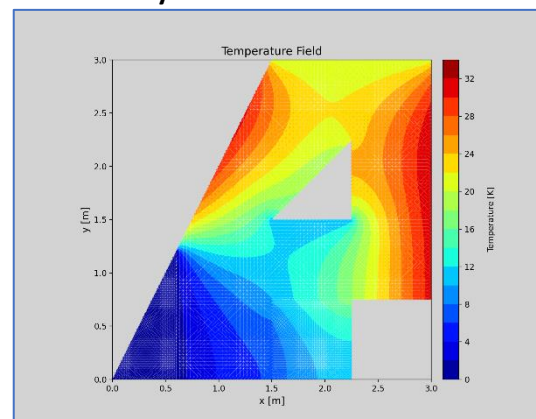
Heat Equation


```
Regions -R-   : 4
Boundaries -B- : 15
Nodes -N-     : 13
```

Materials:

R-0: k = 5 W/mK
R-1: k = 0.25 W/mK
R-2: k = 1.5 W/mK

BCs:

B-4: q = 2 W/m²   (Neumann)
B-12: T = 10 K   (Dirichlet)
B-10: T = 20 K   (Dirichlet)
B-14: T_{ext} = 15 K, h = 5 W/m²K (Robin)
B-2: T = 0 K   (Dirichlet)
B-11: T_{ext} = 40 K, h = 3 W/m²K (Robin)
B-9: T_{ext} = 40 K, h = 3 W/m²K (Robin)

Solution Reference

Solution TinyFEM

Helmholtz Equation


```
Regions -R-    : 3
Boundaries -B- : 12
Nodes -N-      : 12
```

Materials:

R-0:
c = 340 m/s rho = 1.21 kg/m³

BCs:

```
B-0:  Z = 3000 Pa s/m (Neumann)
B-1:  Z = 3000 Pa s/m (Neumann)
B-2:  Z = 3000 Pa s/m (Neumann)
B-3:  Z = 3000 Pa s/m (Neumann)
B-8:  p = 5 Pa         (Dirichlet)
B-9:  p = 5 Pa         (Dirichlet)
```
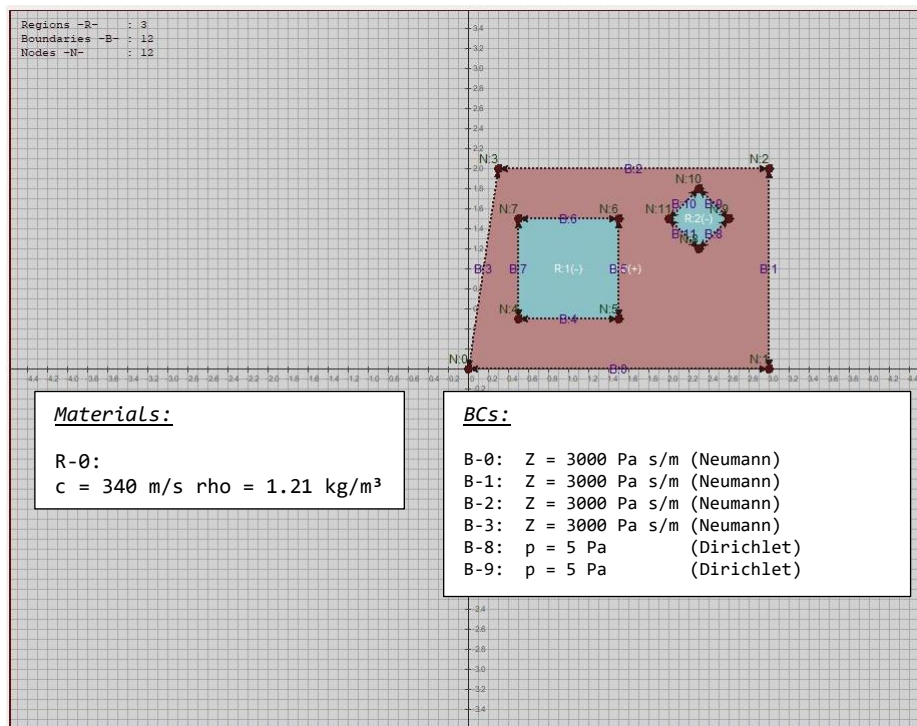
Solution Reference

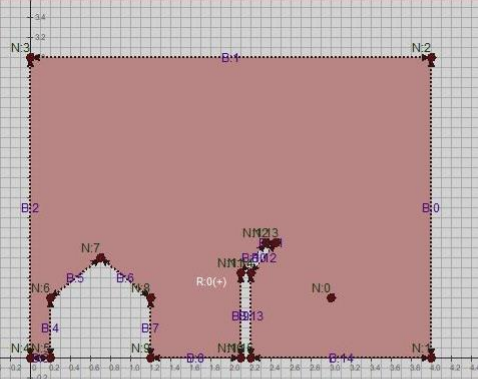*100 Hz*
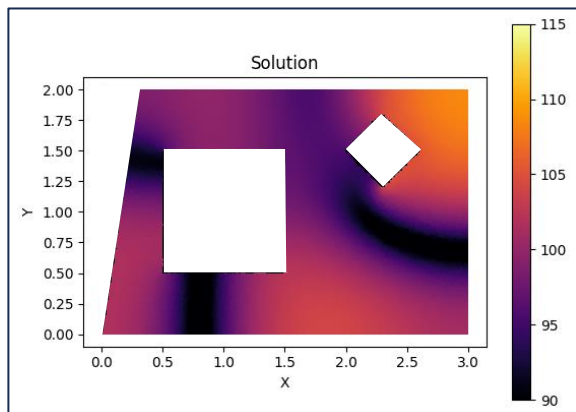
Solution TinyFEM
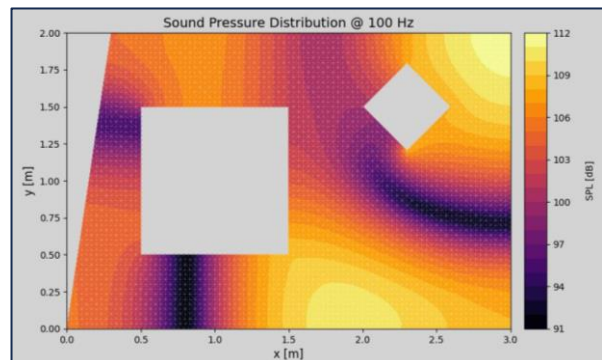
Regions -R- : 1
Boundaries -B- : 15
Nodes -N-   : 16

Materials:

R-0:
c = 340 m/s rho = 1.21 kg/m³

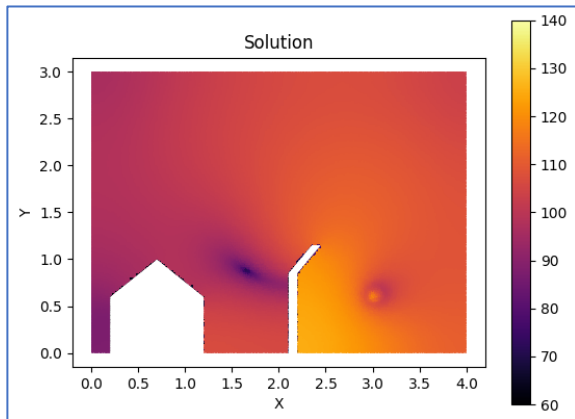**BCs:**

B-0: Z = 411.2 Pa s/m (Neumann)
B-1: Z = 411.2 Pa s/m (Neumann)
B-2: Z = 411.2 Pa s/m (Neumann)

N-0: P = 1 W/m   (Sound Source)

Note: c x rho = 411.2 -> approximation for
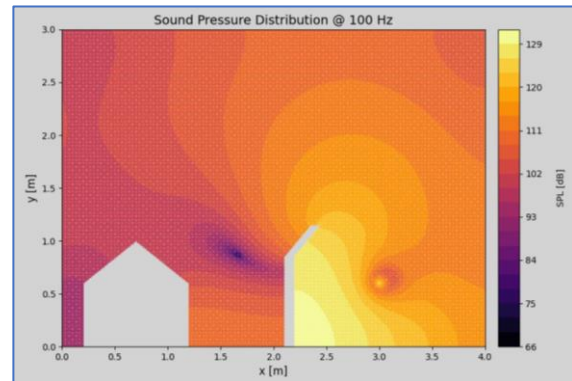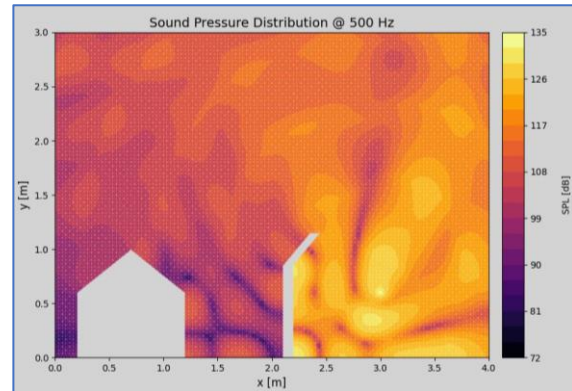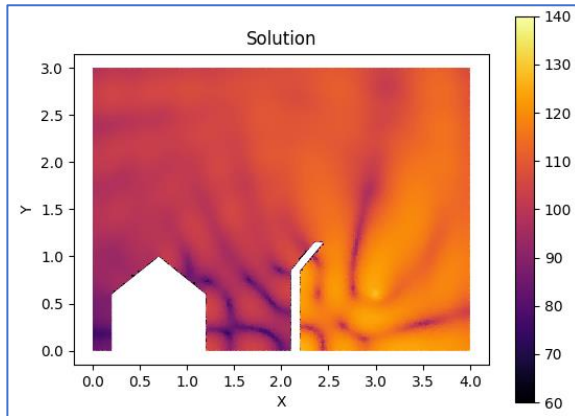absorbing boundary condition

Solution Reference   **Solution TinyFEM**

100 Hz

500 Hz

1000 Hz