# TTLL301 - Heat transfer in a bar with imposed temperature (sinusoid)

**Summary:**

This test is resulting from the validation independent of version 3 in linear transitory thermics.

It is about a linear problem 1D represented by two modelings, one planes, the other voluminal one.

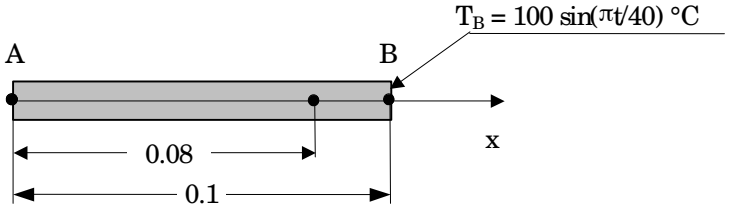
The features tested are the following ones:
1. thermal element plan,
2. voluminal thermal element,
3. transitory algorithm of thermics,
4. limiting conditions: sinusoidal variation of the temperature imposed in the course of time.

The interest of the test lies in the taking into account of the variation in the temperature imposed in the course of time and the geometrical discretization.

The results are compared with those provided by NAFEMS.

# 1 Problem of reference

## 1.1 Geometry




Dimensions in meters

## 1.2 Properties of material

$\lambda = 35\, W/m°C$ thermal conductivity
$C_p = 440.5\, J/kg°C$ specific heat
$\rho = 7200\, kg/m^3$ density

## 1.3 Boundary conditions and loadings

- temperature imposed on the point $A$ : $T_A = 0°C$,
- temperature imposed on the point $B$ : $T_B = 100 \sin(\pi\, t/40)°C$.

## 1.4 Initial conditions

$t = 0$ : $T(x) = 0°C$

# 2 Reference solution

## 2.1 Method of calculating used for the reference solution

The reference solution is that given in the card “TEST n° T3” of the tests of reference published by NAFEMS.

## 2.2 Results of reference

Temperature at the point $x=0.08$ at the moment $t=32\,s$

## 2.3 Uncertainty on the solution

Nonavailable on card NAFEMS.

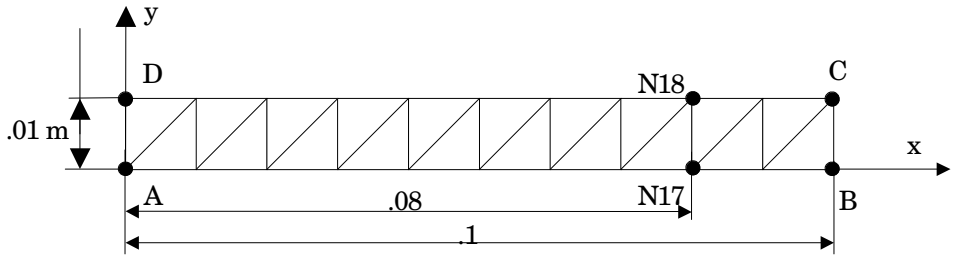
## 2.4 References bibliographical

1. NAFEMS (the National Agency for Finite Element Methods Standard and (the U.K.)) : “Standard The NAFEMS Benchmarks”, TNSB rév 3, October 1990.

# 3 Modeling A

## 3.1 Characteristics of modeling

**PLAN (TRIA3)**




Conditions limites:

- cotés AB CD $\phi = 0$
- coté AD $T = 0\ °C$
- coté BC $T = 100 \sin(\pi t/40)\ °C$

## 3.2 Characteristics of the grid

Many nodes: 22
Many meshs and types: 10 TRIA3

## 3.3 Remarks

The discretization in step of time is the following one:

| | | | |
|---|---|---|---|
| 5 | not for | $[0., 1.0D+0]$ | that is to say $\Delta t = 2.D-1$ |
| 18 | not for | $[1.D+0, 1.0D+1]$ | that is to say $\Delta t = 5.D-1$ |
| 20 | not for | $[1.D+1, 2.0D+1]$ | that is to say $\Delta t = 5.D-1$ |
| 20 | not for | $[2.D+1, 3.0D+1]$ | that is to say $\Delta t = 5.D-1$ |
| 10 | not for | $[3.D+1, 3.5D+1]$ | that is to say $\Delta t = 5.D-1$ |

# 4 Results of modeling A

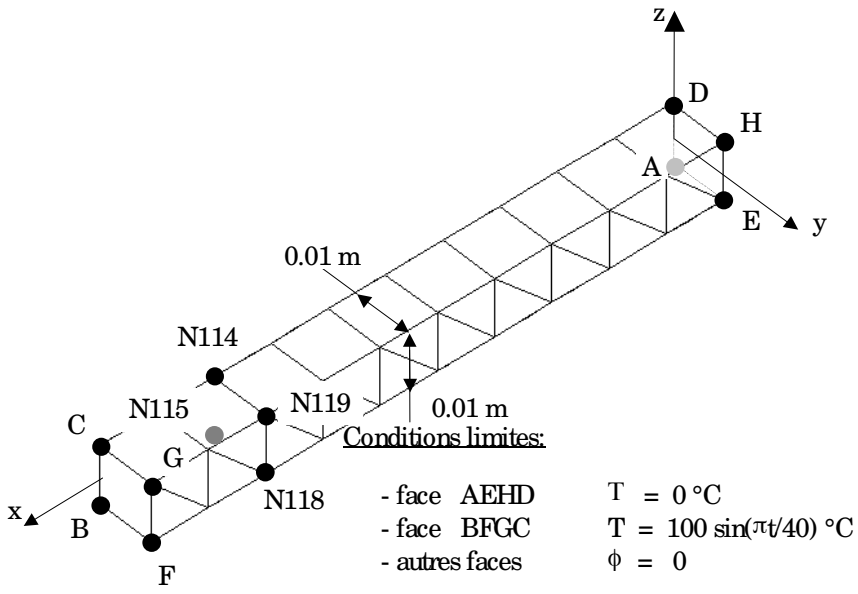
## 4.1 Values tested

| Identification | Reference | % difference | Tolerance |
|---|---|---|---|
| Temperature at the point: $x=0.08\,m$ with $t=32\,s$ | $T(°C)$ | | |
| $N17$ | 36.60 | 3,480 | 2% |
| $N18$ | 36.60 | 1,036 | 2% |

# 5 Modeling B

## 5.1 Characteristics of modeling

**Modeling: 3D (PENTA15)**




## 5.2 Characteristics of the grid

| | |
|---|---|
| Many nodes: | 148 |
| Many meshs and types: | 20 PENTA15 |

## 5.3 Remarks

The discretization in step of time is the following one:

| | | | | |
|---|---|---|---|---|
| 5 | not for | $[0.,1.0D+0]$ | that is to say | $\Delta t=2.D-1$ |
| 18 | not for | $[1.D+0,1.0D+1]$ | that is to say | $\Delta t=5.D-1$ |
| 20 | not for | $[1.D+1,2.0D+1]$ | that is to say | $\Delta t=5.D-1$ |
| 20 | not for | $[2.D+1,3.0D+1]$ | that is to say | $\Delta t=5.D-1$ |
| 10 | not for | $[3.D+1,3.5D+1]$ | that is to say | $\Delta t=5.D-1$ |

# 6 Results of modeling B

## 6.1 Values tested

| Identification | Reference | Tolerance |
|---|---|---|
| Temperature at the point: $x=0.08\,m$ with $t=32\,s$ | | |
| $N114$ | 36.60 | 2% |
| $N115$ | 36.60 | 2% |
| $N118$ | 36.60 | 2% |
| $N119$ | 36.60 | 2% |

# 7 Summary of the results

This test is recommended by NAFEMS (but with another type of mesh).
Two modelings carried out give the following results:

- modeling A (PLAN with meshs TRIA3), the maximum change (3.48%) is higher than the tolerance fixed initially (2%),
- modeling B (3D with meshs PENTA15), the maximum change (0.36%) is lower than the tolerance fixed initially (2%).

The limiting condition is given by using the order FORMULA. This choice allows a good representation of the taking into account of sinusoidal the limiting formal requirement.

Quadratic modeling is adapted to simulate this test. A grid finer and balanced for linear modeling would make it possible to get better results.
The results of modeling A are thus regarded as acceptable.

The principal interest of this test is its origin: NAFEMS.