ADLV100 - Piston coupled to a Summarized fluid column

:

Computation in fluid coupling acoustics-structure of the first mode of a system fluide1 - piston fluid 2.

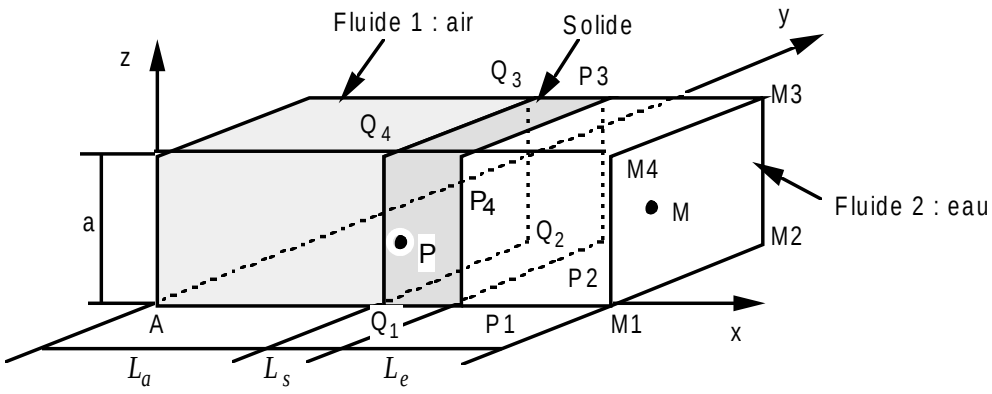
One tests the stiffness matrixes and of mass of the elements of the fluid type and type fluid-structure coupling.

One tests also the boundary condition of type free surface.

Fourteen modelizations are tested.

1 Problem of reference

1.1 Geometry



$L_a = 0.075 \quad L_s = 0.025$, $L_e = 0.05\, m$

constant square section, $a = 0.05\, m$

or circular section (in the axisymmetric case) constant of radius $R = a = 0.05\, m$.

1.2 Properties of the materials

solid: $E = 2.10^{11}\, Pa$	$\rho_s = 7800\, kg/m^3$	$\nu = 0.3$
air: $c_a = 340\, m/s$	$\rho_a = 1.2\, kg/m^3$	
water: $c_e = 1400\, m/s$	$\rho_e = 1000\, kg/m^3$	$c = célérité\ du\ son$

$c =$ speed of sound in the fluid

1.3 Boundary conditions and loading

For all the points M of the face $(M1\,M2\,M3\,M4)$ the pressure and the potential of displacement are null (condition of type free surface),
for the points P of solid, one blocks all the degrees of freedom except the translation in x so that this solid behaves like a piston according to the axis x .

2 Reference solution

2.1 Method of calculating used for the reference solution

To the low frequencies, wave lengths acoustics of motions considered are large compared to the dimension characteristic of fluid volume $(\omega L/c \ll 1)$. The problem is thus monodimensional according to the axis x.

It is shown [bib1] that a light fluid as the air acts primarily as an added stiffness while a heavy fluid behaves only like one added mass. One can thus calculate the first eigenfrequency of the system:

$$\omega = \sqrt{\frac{k}{m}} \qquad \text{avec} \qquad \begin{aligned} k &= k_{air} = \rho_a c_a^2 \frac{S}{L_a} \\ m &= m_s + m_e = \rho_s L_s S + \rho_e L_e S \end{aligned}$$

Soit,

$$\omega = \sqrt{\frac{\rho_a c_a^2}{L_a\left(\rho_s L_s + \rho_e L_e\right)}}$$

Note:

The first own pulsation ω of the system checks well $(\omega L/c \ll 1)$.

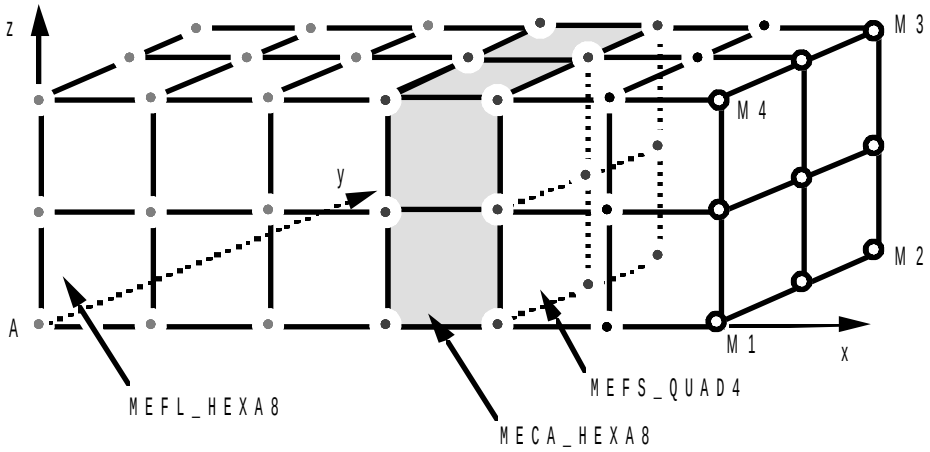
2.2 Bibliographical references

1) GIBERT - Vibrations of Structures. Interactions with the fluids. Random sources of excitation - Collection of the Management of the Studies and Searches of EDF.

3 Modelization A

3.1 Characteristic of the modelization

Elements MECA_HEXA8, MEFL_HEXA8, MEFS_QUAD4



Boundary conditions:

in all the nodes of face M

DDL_IMPO: (GROUP_NO: noeusurfPRES: 0. PHI: 0.)

in all the nodes of piston

(GROUP_NO: noeupistDY : 0. DZ: 0.)

3.2 Characteristics of the mesh

Many nodes:	63
Number of meshes and types:	24 HEXA8, 8 QUAD4

3.3 Values tested

Frequency (Hz)

Reference	*Aster*	Error (%)
13.8285	13.8277	< 0.01

3.4 Remarks

Computations of modes carried out by:

MODE_ITER_SIMULTOPTION : "TAPE"
LIST_FREQ (10. , 20.)

One does not know the analytical solution of the first eigenvector.

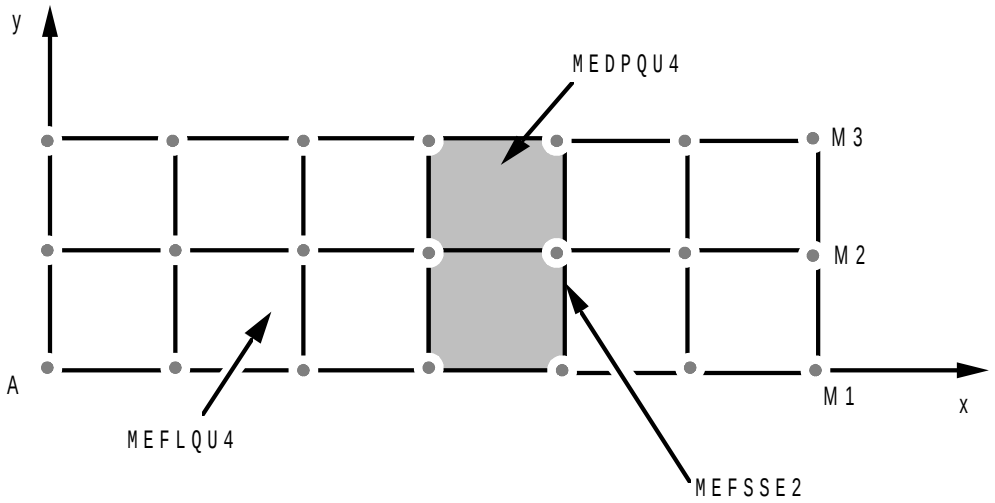
Contents of the file results:

Value of the first eigenfrequency of vibration of the coupled system.

4 Modelization B

4.1 Characteristic of the modelization

Elements MEDPQU4, MEFLQU4, MEFSSE2



Boundary conditions:

in all the nodes of face M

```
DDL_IMPO:     (GROUP_NO: noeusurfPRES: 0. PHI: 0.)
```

in all the nodes of piston

```
              (GROUP_NO: noeupistDY  : 0.)
```

4.2 Characteristics of the mesh

Many nodes: 21
Number of meshes and types: 12 QUAD4, 4 SEG2

4.3 Values tested

Frequency (Hz)

Reference	*Aster*	Error (%)
13.8285	13.8277	< 0.01

4.4 Remarks

Computations carried out by:

```
MODE_ITER_SIMULTOPTION     : "TAPE"
                         Freq (10. , 20.)
```

One does not know the analytical solution of the first eigenvector.

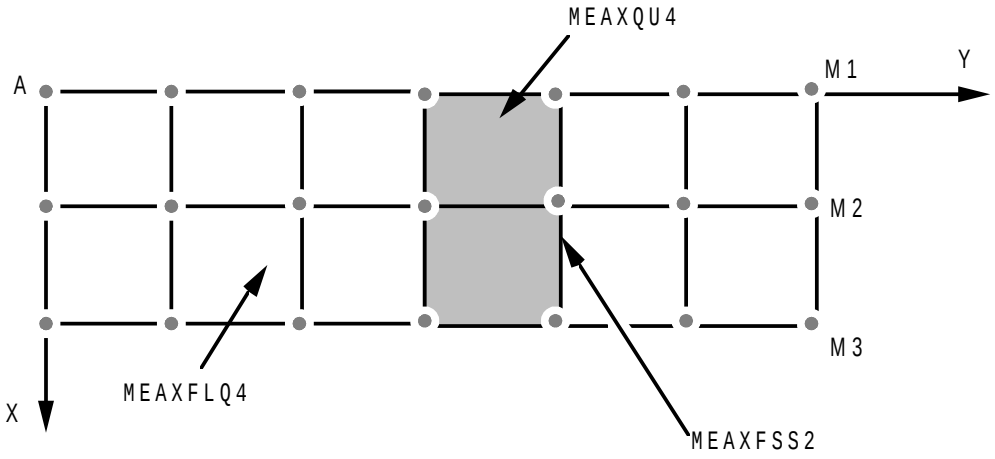
Contents of the file results:

Value of the first eigenfrequency of vibration of the coupled system.

5 Modelization C

5.1 Characteristic of the modelization

Elements MEAXQU4, MEAXFLQ4, MEAXFSS2



Boundary conditions:

in all the nodes of face M

```
DDL_IMPO:     (GROUP_NO: noeusurfPRES: 0. PHI: 0.)
```

in all the nodes of piston

```
              (GROUP_NO: noeupistDY  : 0.)
```

Not $M1:N019 \quad M2:N020 \quad M3:N021$, $A:N01$

5.2 Characteristic of the mesh

Many nodes: 21
Number of meshes and types: 12 QUAD4, 4 SEG2

5.3 Values tested

Frequency (Hz)

Reference	*Aster*	Error (%)
13.8285	13.8277	< 0.01

5.4 Remarks

Computations carried out by:

```
MODE_ITER_SIMULTOPTION     : "TAPE"
                        FREQ (10. , 20.)
```

One does not know the analytical solution of the first eigenvector.

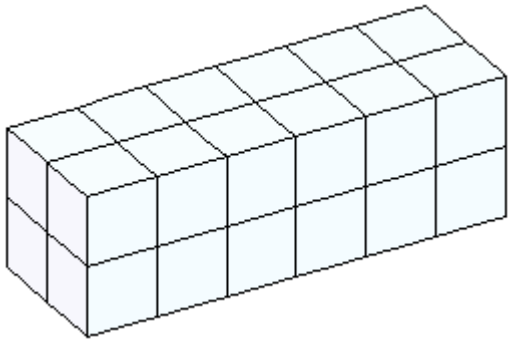
Contents of the file results:

Value of the first eigenfrequency of vibration of the coupled system.

6 Modelization D

6.1 Characteristic of the modelization

Elements MECA_HEXA20, MEFL_HEXA20, MESF_QUAD8



Boundary conditions:
in all the nodes of face M

```
DDL_IMPO:     (GROUP_NO: noeusurfPRES: 0. PHI: 0.)
```

in all the nodes of piston

```
              (GROUP_NO: noeupistDY  : 0. DZ: 0.)
```

6.2 Characteristics of the mesh

Many nodes: 201
Number of meshes and types: 24 HEXA20, 8 QUAD8

6.3 Values tested

Frequency (Hz)

Reference	*Aster*	Error (%)
13.8285	13.8277	-0.006

6.4 Remarks

Computations of modes carried out by:

```
MODE_ITER_INVoption    : List_freq (10
                       "ADJUSTS". , 20.)
```

One does not know the analytical solution of the first eigenvector.

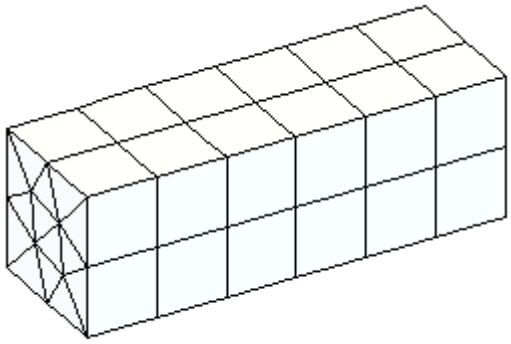
Contents of the file results:

Value of the first eigenfrequency of vibration of the coupled system.

7 Modelization E

7.1 Characteristic of the modelization

Elements MECA_PENTA15, MEFL_PENTA15, MESF_TRIA6



Boundary conditions:
in all the nodes of face M

```
DDL_IMPO:     (GROUP_NO: noeusurfPRES: 0. PHI: 0.)
```

in all the nodes of piston

```
              (GROUP_NO: noeupistDY  : 0. DZ: 0.)
```

7.2 Characteristics of the mesh

Many nodes: 331
Number of meshes and types: 84 PENTA15, 28 TRIA6

7.3 Values tested

Frequency (Hz)

Reference	*Aster*	Error (%)
13.8285	13.8277	-0.006

7.4 Remarks

Computations of modes carried out by:

```
MODE_ITER_INVoption     : List_freq (10
                        "ADJUSTS". , 20.)
```

One does not know the analytical solution of the first eigenvector.

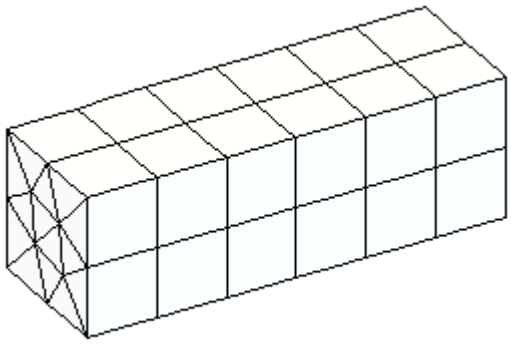
Contents of the file results:

Value of the first eigenfrequency of vibration of the coupled system.

8 Modelization F

8.1 Characteristic of the modelization

Elements MECA_PENTA6, MEFL_PENTA6, MESF_TRIA3



Boundary conditions:
in all the nodes of face M

```
DDL_IMPO:     (GROUP_NO: noeusurfPRES: 0. PHI: 0.)
```

in all the nodes of piston

```
              (GROUP_NO: noeupistDY  : 0. DZ: 0.)
```

8.2 Characteristics of the mesh

Many nodes: 84
Number of meshes and types: 84 PENTA6, 28 TRIA3

8.3 Values tested

Frequency (Hz)

Reference	*Aster*	Error (%)
13.8285	13.8277	-0.006

8.4 Remarks

Computations of modes carried out by:

```
MODE_ITER_INVoption    : List_freq (10
                       "ADJUSTS". , 20.)
```

One does not know the analytical solution of the first eigenvector.

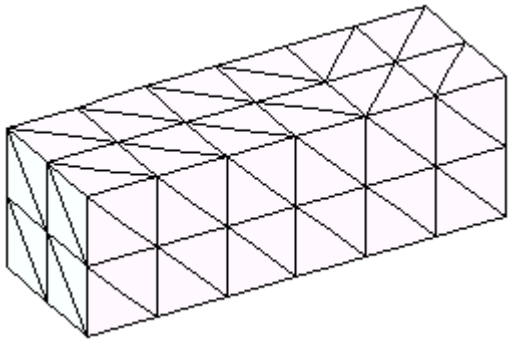
Contents of the file results:

Value of the first eigenfrequency of vibration of the coupled system.

9 Modelization G

9.1 Characteristic of the modelization

Elements MECA_TETRA10, MEFL_TETRA10, MESF_TRIA6



Boundary conditions:
in all the nodes of face M

```
DDL_IMPO:     (GROUP_NO: noeusurfPRES: 0. PHI: 0.)
```

in all the nodes of piston

```
              (GROUP_NO: noeupistDY  : 0. DZ: 0.)
```

9.2 Characteristics of the mesh

Many nodes: 366
Number of meshes and types: 173 TETRA10, 16 TRIA6

9.3 Values tested

Frequency (Hz)

Reference	*Aster*	Error (%)
13.8285	13.8277	-0.006

9.4 Remarks

Computations of modes carried out by:

```
MODE_ITER_INVoption    : List_freq (10
                       "ADJUSTS". , 20.)
```

One does not know the analytical solution of the first eigenvector.

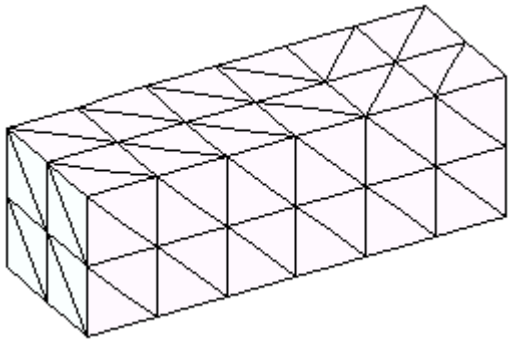
Contents of the file results:

Value of the first eigenfrequency of vibration of the coupled system.

10 Modelization H

10.1 Characteristic of the modelization

Elements MECA_TETRA4, MEFL_TETRA4, MESF_TRIA3



Boundary conditions:
in all the nodes of face M

```
DDL_IMPO:     (GROUP_NO: noeusurfPRES: 0. PHI: 0.)
```

in all the nodes of piston

```
              (GROUP_NO: noeupistDY  : 0. DZ: 0.)
```

10.2 Characteristics of the mesh

Many nodes: 69
Number of meshes and types: 173 TETRA4, 16 TRIA3

10.3 Values tested

Frequency (Hz)

Reference	*Aster*	Error (%)
13.8285	13.8277	-0.006

10.4 Remarks

Computations of modes carried out by:

```
MODE_ITER_INVoption    : List_freq (10
                       "ADJUSTS". , 20.)
```

One does not know the analytical solution of the first eigenvector.

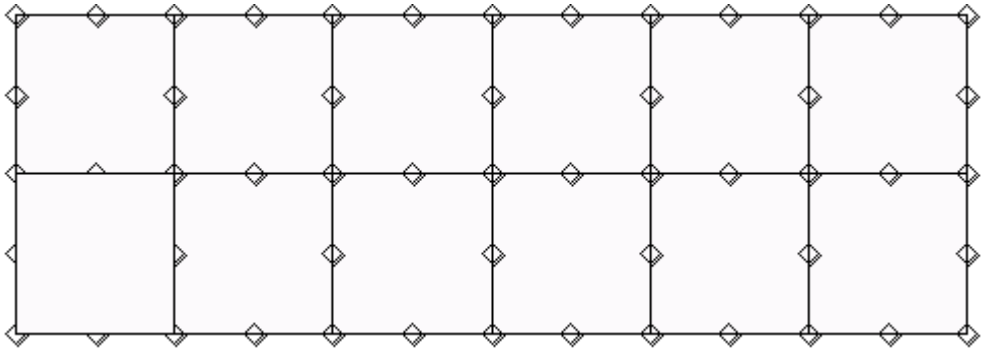
Contents of the file results:

Value of the first eigenfrequency of vibration of the coupled system.

11 Modelization I

11.1 Characteristic of the modelization

Elements MEDPQU8, MEFLQU8, MEFSSE3



Boundary conditions:
in all the nodes of face M

```
DDL_IMPO:     (GROUP_NO: noeusurfPRES: 0. PHI: 0.)
```

in all the nodes of piston

```
              (GROUP_NO: noeupistDY  : 0.)
```

11.2 Characteristics of the mesh

Many nodes: 53
Number of meshes and types: 12 QUAD8, 4 SEG3

11.3 Values tested

Frequency (Hz)

Reference	*Aster*	Error (%)
13.8285	13.8277	-0.006

11.4 Remarks

Computations carried out by:

```
MODE_ITER_INVoption     : Freq (10
                        "ADJUSTS". , 20.)
```

One does not know the analytical solution of the first eigenvector.

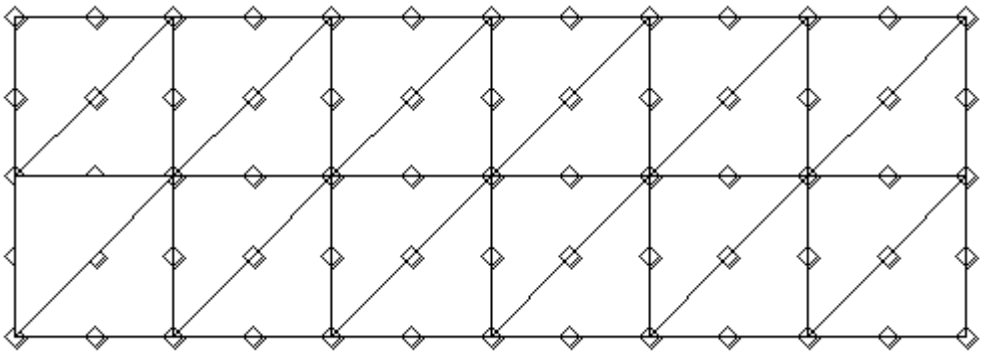
Contents of the file results:

Value of the first eigenfrequency of vibration of the coupled system.

12 Modelization J

12.1 Characteristic of the modelization

Elements MEDPTR6, MEFLTR6, MEFSSE3



Boundary conditions:
in all the nodes of face M

```
DDL_IMPO:     (GROUP_NO: noeusurfPRES: 0. PHI: 0.)
```

in all the nodes of piston

```
              (GROUP_NO: noeupistDY  : 0.)
```

12.2 Characteristics of the mesh

Many nodes: 65
Number of meshes and types: 24 TRIA6, 4 SEG3

12.3 Values tested

Frequency (Hz)

Reference	*Aster*	Error (%)
13.8285	13.8277	-0.006

12.4 Remarks

Computations carried out by:

```
MODE_ITER_INVoption     : Freq (10
                        "ADJUSTS". , 20.)
```

One does not know the analytical solution of the first eigenvector.

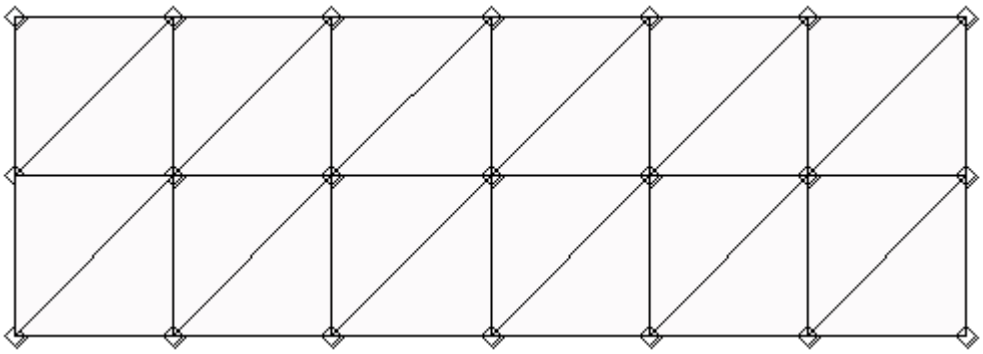
Contents of the file results:

Value of the first eigenfrequency of vibration of the coupled system.

13 Modelization K

13.1 Characteristic of the modelization

Elements MEDPTR3, MEFLT3, MEFSSE2



Boundary conditions:
in all the nodes of face M

```
DDL_IMPO:     (GROUP_NO: noeusurfPRES: 0. PHI: 0.)
```

in all the nodes of piston

```
              (GROUP_NO: noeupistDY  : 0.)
```

13.2 Characteristics of the mesh

Many nodes: 65
Number of meshes and types: 24 TRIA3, 4 SEG2

13.3 Values tested

Frequency (Hz)

Reference	*Aster*	Error (%)
13.8285	13.8277	-0.006

13.4 Remarks

Computations carried out by:

```
MODE_ITER_INVoption     : Freq (10
                        "ADJUSTS". , 20.)
```

One does not know the analytical solution of the first eigenvector.

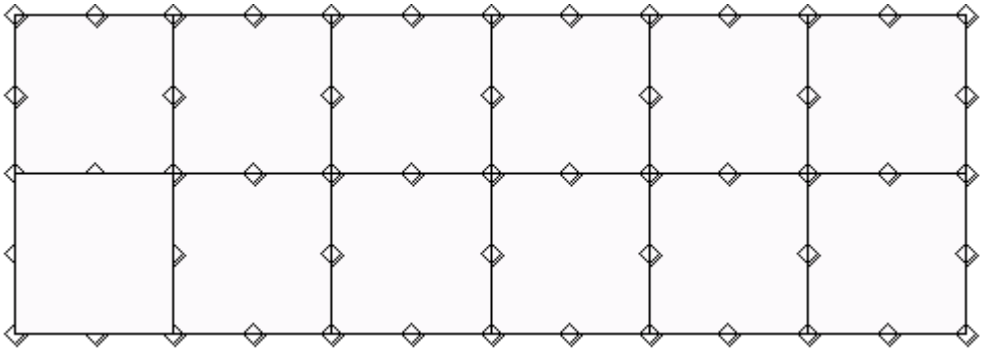
Contents of the file results:

Value of the first eigenfrequency of vibration of the coupled system.

14 Modelization L

14.1 Characteristic of the modelization

Elements MEAXQU8, MEAXFLQU8, MEAXFSSE3



Boundary conditions:
in all the nodes of face M

```
DDL_IMPO:     (GROUP_NO: noeusurfPRES: 0. PHI: 0.)
```

in all the nodes of piston

```
              (GROUP_NO: noeupistDY  : 0.)
```

14.2 Characteristics of the mesh

Many nodes:	53
Number of meshes and types:	12 QUAD8, 4 SEG3

14.3 Values tested

Frequency (Hz)

Reference	*Aster*	Error (%)
13.8285	13.8277	-0.006

14.4 MODE_ITER_INVoption

```
Remarks       : Freq (10
                      "ADJUSTS". , 20.)
```

One does not know the analytical solution of the first eigenvector.

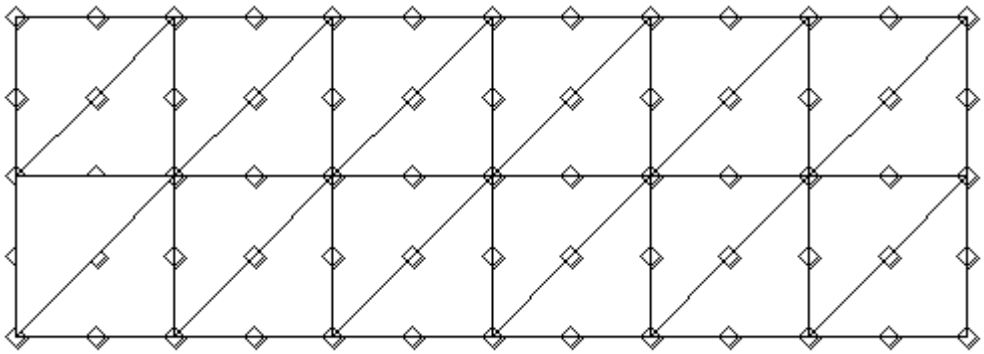
Contents of the file results:

Value of the first eigenfrequency of vibration of the coupled system.

15 Modelization M

15.1 Characteristic of the modelization

Elements MEAXTR6, MEAXFLTR6, MEAXFSSE3



Boundary conditions:
in all the nodes of face M

```
DDL_IMPO:     (GROUP_NO: noeusurfPRES: 0. PHI: 0.)
```

in all the nodes of piston

```
              (GROUP_NO: noeupistDY  : 0.)
```

15.2 Characteristics of the mesh

Many nodes: 65
Number of meshes and types: 24 TRIA6, 4 SEG3

15.3 Values tested

Frequency (Hz)

Reference	*Aster*	Error (%)
13.8285	13.8277	-0.006

15.4 MODE_ITER_INVoption

```
Remarks       : Freq (10
                      "ADJUSTS". , 20.)
```

One does not know the analytical solution of the first eigenvector.

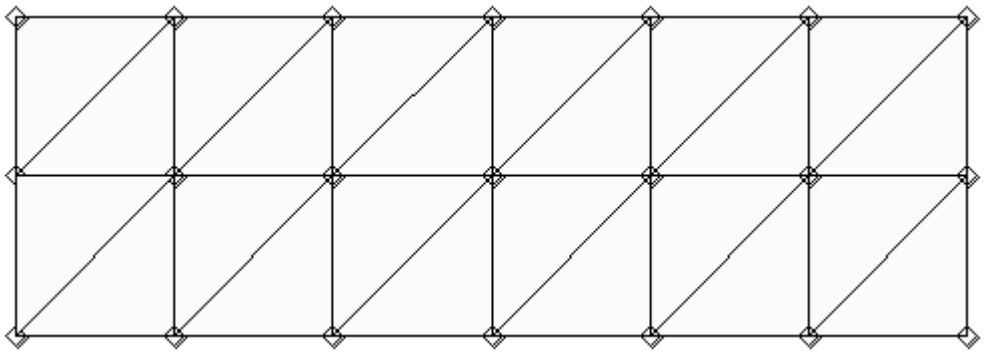
Contents of the file results:

Value of the first eigenfrequency of vibration of the coupled system.

16 Modelization N

16.1 Characteristic of the modelization

Elements MEAXTR3, MEAXFLTR3, MEAXFSSE2



Boundary conditions:
in all the nodes of face M

```
DDL_IMPO:     (GROUP_NO: noeusurfPRES: 0. PHI: 0.)
```

in all the nodes of piston

```
              (GROUP_NO: noeupistDY  : 0.)
```

16.2 Characteristics of the mesh

Many nodes: 21
Number of meshes and types: 24 TRIA6, 4 SEG3

16.3 Values tested

Frequency (Hz)

Reference	*Aster*	Error (%)
13.8285	13.8277	-0.006

16.4 MODE_ITER_INVoption

```
Remarks       : Freq (10
                      "ADJUSTS". , 20.)
```

One does not know the analytical solution of the first eigenvector.

Contents of the file results:

Value of the first eigenfrequency of vibration of the coupled system.

17 Summary of the results

the value of the modal frequency obtained with *Code_Aster* is satisfactory since, with a moderated discretization, it is equal to 0,01% close with the theoretical solution, whatever the type of modelization.