

## FDLV104 - Calculation of mass added on model generalized 3D

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### Summary:

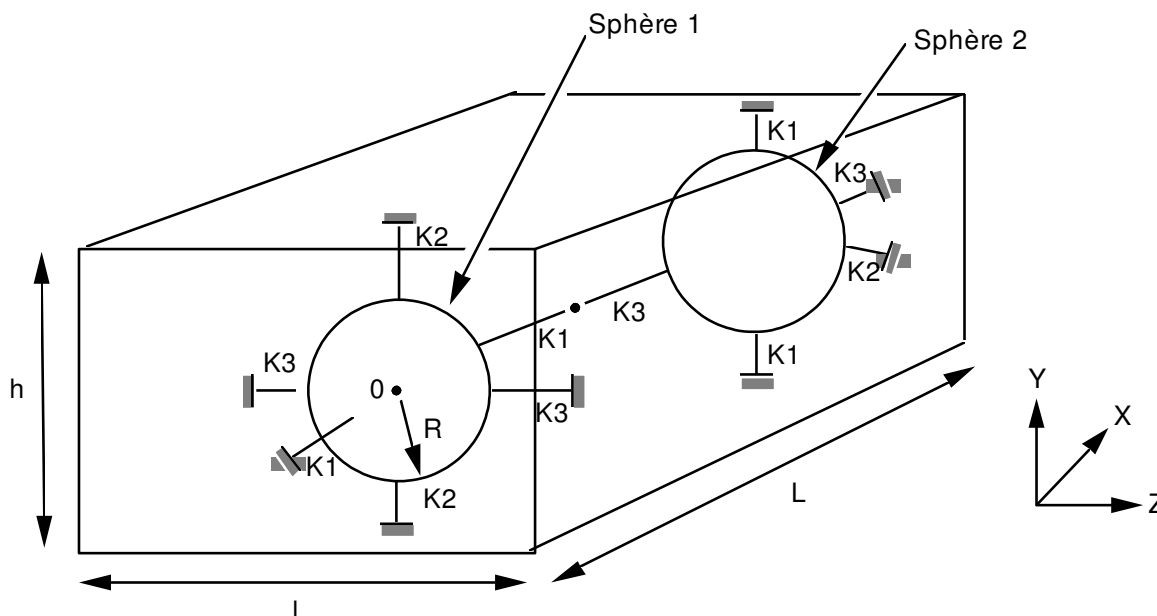
This test of the field of the fluids (fluid coupling/structure) validates the calculation of mass added on a generalized model of type 3D, namely two spheres coupled by an incompressible fluid.

By a modal analysis carried out by dynamic under-structuring, one obtains the coupled modes of the two spheres because of the presence of the fluid. The Eigen frequencies are compared with those determined by a direct calculation.

One obtains the Eigen frequencies with a margin of less than 3%.

## 1 Problem of reference

### 1.1 Geometry



Length:	$L = 4\text{ m}$
width:	$l = 2\text{ m}$
height:	$h = 2\text{ m}$
Thickness of the hulls:	$e = 10^{-3}\text{ m}$
Ray of the spheres:	$R = 0.5\text{ m}$

### 1.2 Properties of materials

Structure: steel - material elastic

$$E = 2.10^{11}\text{ Pa}$$

$$\nu = 0.3$$

$$\rho_s = 7800\text{ kg/m}^3$$

The springs have as respective stiffnesses:

$$K1 = 10^6\text{ N/m}$$

$$K2 = 10^5\text{ N/m}$$

$$K3 = 10^7\text{ N/m}$$

Fluid: water - thermal material are equivalent

$$\lambda = 1.$$

the specific heat plays the part of density of the fluid:  $\rho_f = 1000\text{ kg/m}^3$

### 1.3 Boundary conditions and loadings

Side structure: degrees of freedom of rotation  $DRX$ ,  $DRY$ ,  $DRZ$  sphere 1 are blocked:

$$DRX: 0.0 \quad DRY \text{ MARTINI}: 0.0 \quad DRZ: 0.0$$

Fluid side: one imposes a pressure (i.e temperature) worthless in a node of the fluid grid.

## 2 Reference solution

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### 2.1 Method of calculating used for the reference solution

One uses a direct modal calculation to obtain the Eigen frequencies modified by the fluid around the spheres.

The two spheres result by a translation from vector from components (2, 0., 0.) and for a rotation of nautical analyses (90., 0., 90.) what makes it possible to plan to build a model generalized on the 1st sphere. One will be able to carry out same modal calculation with fluid coupling/structure by using the dynamic under-structuring. Calculation **direct** with taking into account of added mass leads to the Eigen frequencies of the immersed system following:

$$\begin{aligned}f_1 &= 3.1172 \text{ Hz} \\f_2 &= 3.1183 \text{ Hz} \\f_3 &= 9.2727 \text{ Hz} \\f_4 &= 9.8267 \text{ Hz} \\f_5 &= 22.4400 \text{ Hz} \\f_6 &= 30.3295 \text{ Hz}\end{aligned}$$

### 2.2 Results of reference

Direct modal calculation by *Code\_Aster*.

### 2.3 Uncertainty on the solution

Uncertainties on the solution are related on the discretization of the fluid interface/structure and to invariance of the grid by rotation of nautical angles (90°, 0°, 90°).

## 3 Modeling A

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### 3.1 Characteristics of modeling

Modeling understands:

- side structure:  
336 elements of hulls `DKT` modelling sphere 1,  
6 discrete elements of type `K_TR_L` (modeling `DIS_TR`) modelling the six springs connecting sphere 1 to the solid mass,
- fluid side:  
672 `THER_FACE3` thermal elements modelling the fluid interface/structure,  
39,445 `THER_TETRA4` thermal elements modelling the fluid.

### 3.2 Characteristics of the grid

Many meshes and types: 672 meshes `TRIA3`, 39,445 `TETRA4`, 6 `SEG2`

### 3.3 Values tested

Identification	Hz
	Reference
N°1 mode	3.1172
N°2 mode	3.1183
N°3 mode	9.2727
N°4 mode	9.8267
N°5 mode	22.4400
N°6 mode	30.3295

### 3.4 Remarks

The variation on the two last Eigen frequencies is explained by a not-symmetry of the grid of the fluid interface/structure (thermal) compared to that of the first. **grid** fluid interface/structure (thermal elements) of the second sphere does not result exactly from that from the first by rotation from nautical angles from  $90^\circ, 0^\circ, 90^\circ$ .

## 4 Summary of the results

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The results got by calculation by dynamic under-structuring show a perfect agreement with direct calculation. Nevertheless, to have this agreement, it should be taken care that the grids of the interfaces fluid/structure (thermal elements) of the substructures which are repeated inside the fluid grid deduce perfectly by rotations of nautical angle defined in `DEFI_MODELE_GENE`.