

## FDLV103 - Separate concentric spheres by an incompressible fluid

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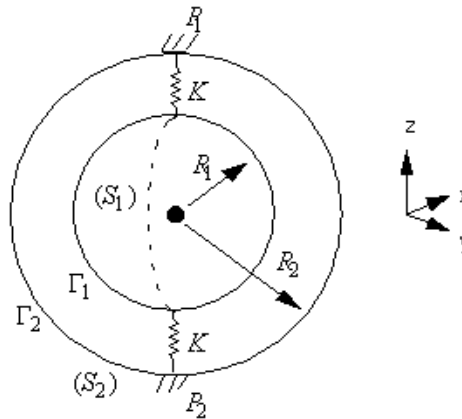
### Summary:

This test relates to the field of the fluids in the aspect inertial coupling. One carries out a modal analysis of a rigid sphere connected to the solid mass by springs and diving in an incompressible volume of fluid of spherical form.

The test validates the calculation of mass added in 3D as well as modal calculation for a system fluid-structure coupled in 3D.

## 1 Problem of reference

### 1.1 Geometry



The interior sphere ( $S_1$ ) a ray has  $R_1=0.35\text{ m}$ .

The interior sphere ( $S_2$ ) a ray has  $R_2=0.45\text{ m}$ .

### 1.2 Material properties

The interior sphere ( $S_1$ ) is out of steel:

$$\rho_s = 7\,800\text{ kg/m}^3$$

$$E = 2.110^{11}\text{ Pa}$$

$$\nu = 0.3$$

The fluid filling out volume understood enters ( $S_1$ ) and ( $S_2$ ) is water of density  $\rho_f = 1\,000\text{ kg/m}^3$  (equivalent thermal characteristics:  $\lambda = 1$ ,  $\rho_f C_p = 1\,000$ ).

One passes to model the fluid by a thermal modeling 3D.

### 1.3 Boundary conditions and loadings

One supposes a worthless temperature in a point of the fluid grid.

One embeds the springs on the level of the solid mass at the points  $P_1$  and  $P_2$ .

## 2 Reference solution

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

One bases oneself on an analytical result [bib1]:

In the case of two concentric spheres immersed in the same fluid, it is shown that the mass added induced by the fluid confined on the internal sphere ( $S_1$ ) is worth:

$$m_a = \frac{2}{3} \rho_f \pi \left[ \frac{1 + 2 \left( \frac{R_1}{R_2} \right)^3}{1 - \left( \frac{R_1}{R_2} \right)^3} \right] R_1^3$$

If it is supposed that the sphere has one degree of freedom according to  $Oz$ , clean mode of translation of the sphere ( $S_1$ ) according to  $Oz$  is given by:

$$f = \frac{1}{2\pi} \sqrt{\frac{2K}{m + m_a}}$$

Digital application:

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

$$m = 12 \text{ kg}$$

$$m_a = 329.17 \text{ kg}$$

$$F = 3.8534 \text{ Hz}$$

### 2.2 Bibliographical references

1. R.D. BLEVINS, "Formulated for natural frequency and mode shape", ED. KRIEGER

## 3 Modeling A

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### 3.1 Characteristics of modeling

Modeling understands:

- side structure:
  - 2 discrete elements of type `K_TR_L` (mesh SEG2)
  - 1316 elements of hulls of the type `DKT` (mesh TRIA3)
- fluid side:
  - 1316 thermal elements of face of the type `3D` (mesh TRIA3)
  - 14454 thermal elements of volume of the type `3D` (mesh TETRA4)

The nodes of the hull interns are blocked according to all their degrees of freedom of rotation, like their two degrees of freedom of translation `DX` and `DY` (`GROUP_NO`: `NOINT`).

The springs are embedded with the solid mass at the points `P1` and `P2` (`GROUP_NO`: `ENCAST`).

The hulls are thickness 1 *mm* .

### 3.2 Characteristics of the grid

Many meshes and types: 2632 TRIA3, 2 SEG2, 14454 TETRA4.

### 3.3 Values tested

Identification	Reference
Order of the clean mode: 1	3.8534

## 4 Summary of the results

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One finds the values of the analytical results well.

The small variation observed on the added mass can come:

- of a discretization not rather fine of the surface of the sphere,
- or of a discretization not fine enough of fluid volume.