Study of the movement of a subsurface buoy with 5 degrees of freedom

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USE OF SUBSURFACE BUOYS

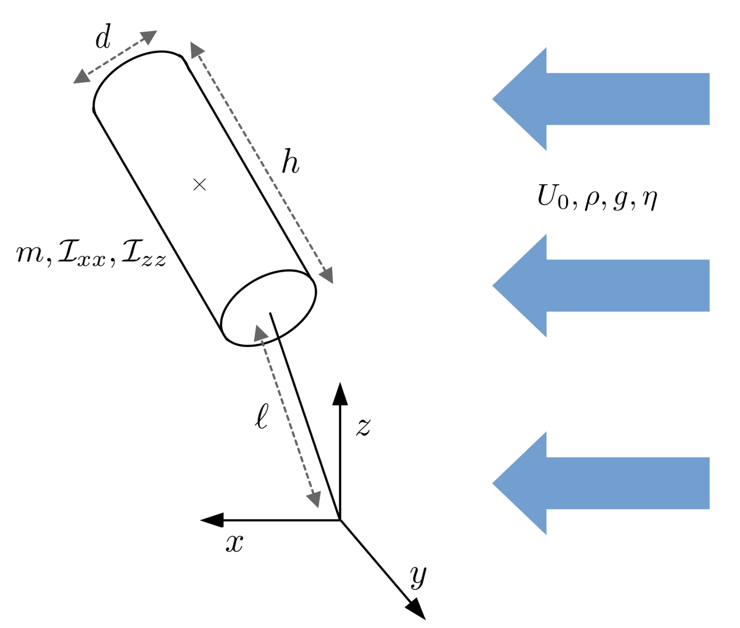
- Subsurface buoys are used in offshore engineering to reduce the mechanical constraints on underwater structures.
- With their cylindrical shape and low mass, they are very sensitive to Vortex Induced Vibrations (VIV)
- Burning issues for oil platforms or floating wind turbines.

OBJECTIVES

- Characterize experimentally the movement of a cylindrical buoy in transverse flow
- Simulate numerically the movement of the buoy with the code CADYF
- Compare experimental and numerical results

MODEL

- A cylindrical tethered buoy submit to a transverse flow



- 3 distances (x_c, y_c, z_c) to describe the position of the center of mass of the buoy
- 3 angles $(\theta_x, \theta_y, \theta_z)$ to describe the orientation of the buoy
- 1 constraint (the cable is inextensible)

Thus, **a 5 degrees of freedom model**

PARAMETERS AND DIMENSIONLESS NUMBERS

d : diameter of the cylindrical buoy
h : height of the buoy
l : length of the cable
U_0 : flow velocity
g : standard gravity
η : dynamic viscosity of the fluid
ρ : density of the fluid
m : mass of the buoy
$\mathcal{I}_{xx}$: inertia around x-axis
$\mathcal{I}_{zz}$: inertia around z-axis
f_0 : natural frequency (depends on the other parameters)

$Re = \frac{\rho U_0 d}{\eta}$: Reynolds number

$\mathcal{M} = \frac{\rho h d^2}{4m}$: Mass Number

$U_r = \frac{U_0}{f_0 d}$: Reduced Velocity

$h^* = \frac{h}{d}, \ell^* = \frac{\ell}{d}$: Geometrical ratios

$\mathcal{I}^*_{xx} = \frac{48\mathcal{I}_{xx}}{m(3d^2+4h^2)}$: Inertial Ratios

$\mathcal{I}^*_{zz} = \frac{8\mathcal{I}_{zz}}{md^2}$

EXPERIENCES

Infrastructures :

Use of the hydrodynamic loop of the A106 room of EPM. The hydrodynamic tunnel where experiments are carried out has a squared section of 25 cm.

Use of the hydrodynamic loop of the A106 room

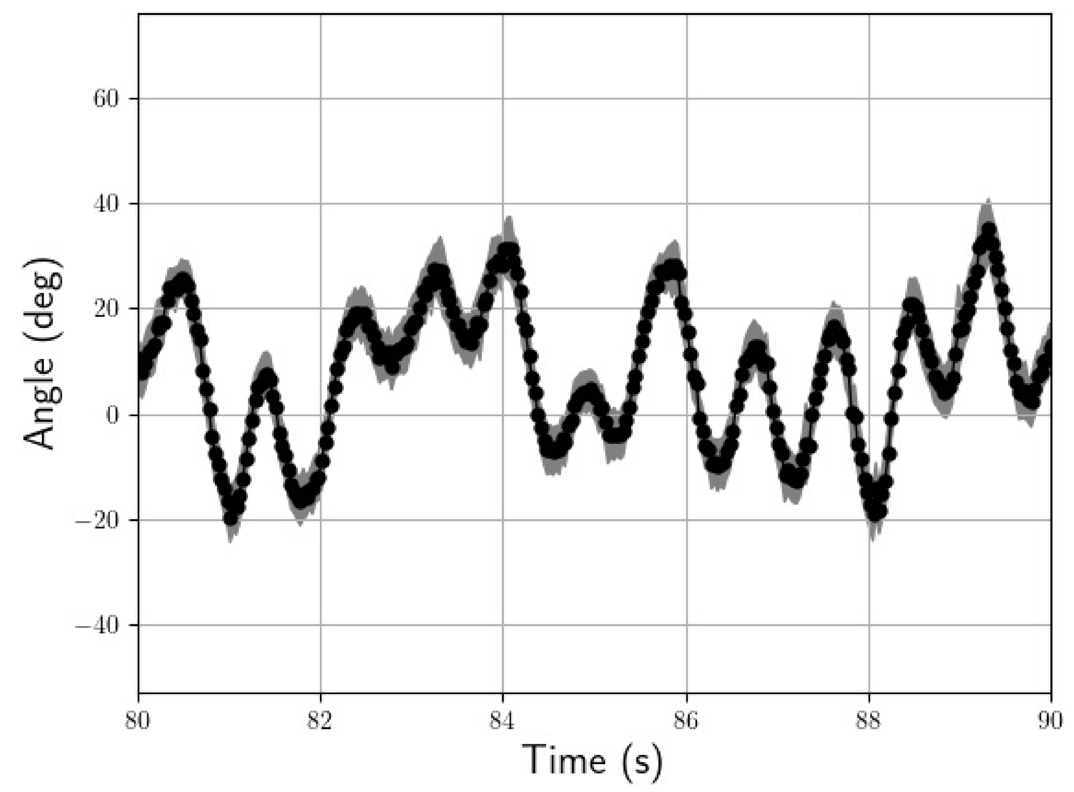
Hydrodynamic conditions :

$$Re = 0 - 9 \times 10^3$$
$$\mathcal{M} = 0.2$$
$$U_r = 0 - 12$$

Methodology :

The buoy in transverse flow is filmed with a SLR camera, and its position is reconstructed with image analysis methods.

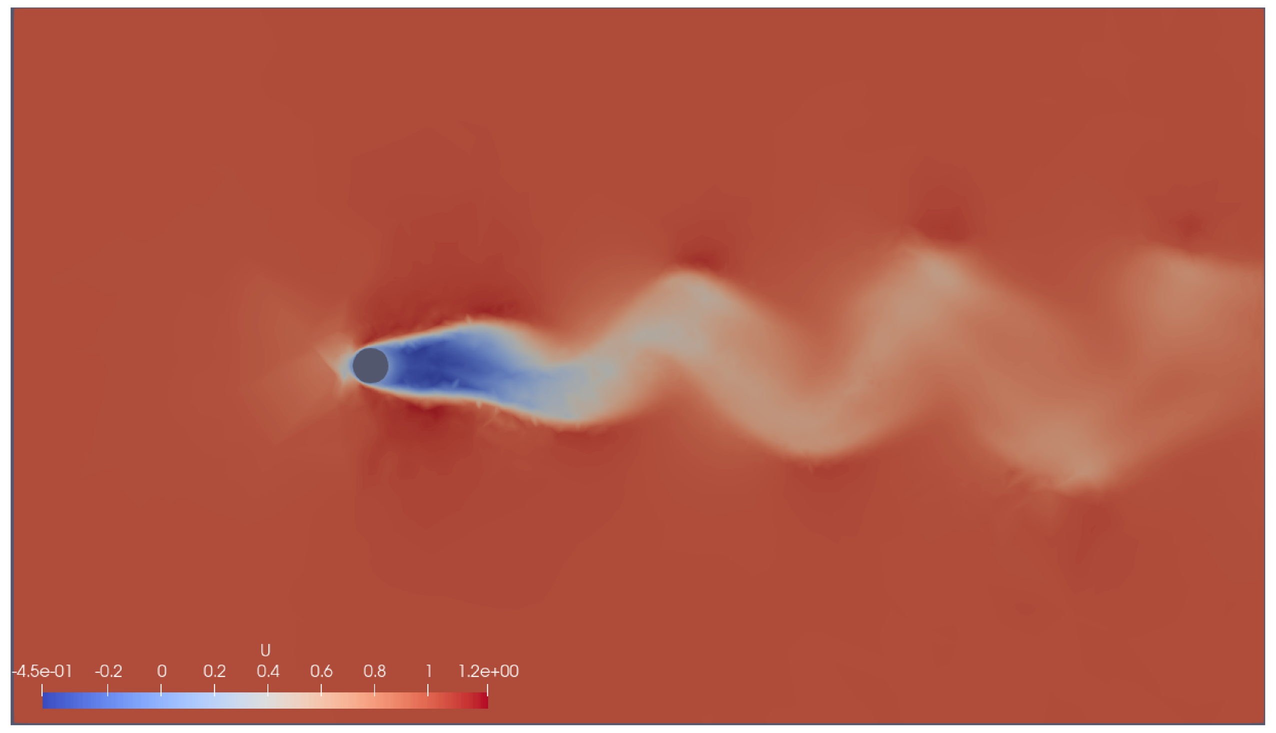
Example of trajectory for angle θ_z at $U_r = 6.80$:



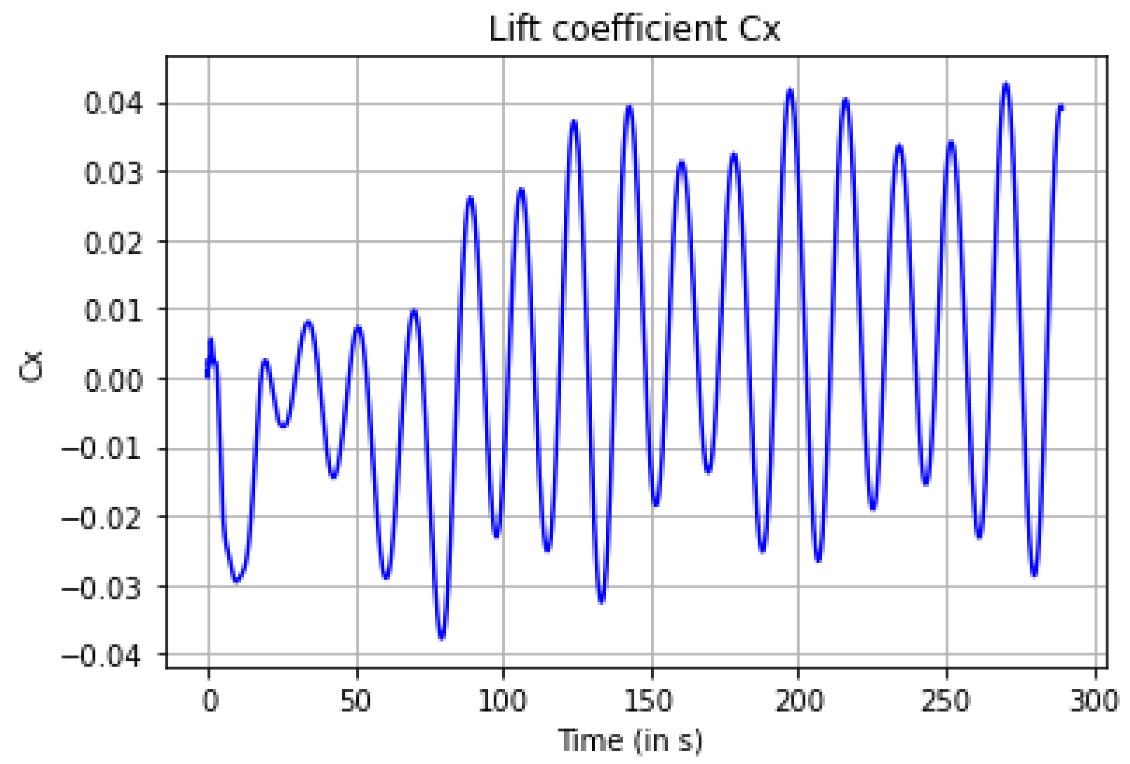
NUMERICAL SIMULATIONS

CFD :

Use of the code CADYF. CADYF is a monolithic FEM code for fluid mechanics and fluid structure interactions.



Karman Vortex Street behind a fixed cylinder at Re = 200 with CADYF



Lift coefficient Cx at Re = 200

Hydrodynamic conditions :

$$Re = \text{ up to } 5 \times 10^2$$
$$\mathcal{M} = \text{no constraint}$$
$$U_r = \text{no constraint}$$

Actual work :

Developpement and implementation of specific equations for the translation and rotation of a tethered cylindrical buoy

ACKNOWLEDGMENTS

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