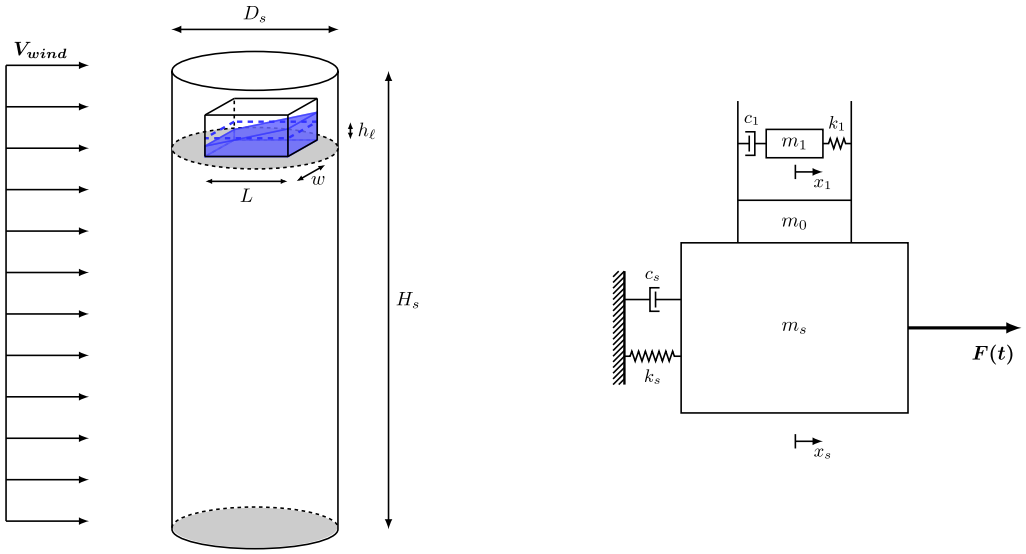
Exercises – Serie 10 – Sloshing dynamics

Exercise 1 – Tuned Liquid damper.

Consider a tall building represented by a cylinder with an equivalent diameter, $D_s = 50$ m and a total height $H_s = 300$ m as depicted on figure 1. The structure is subjected to strong winds, vortices are periodically shed from its surface thus forcing the structure to oscillate. To dampen those oscillations, a tuned liquid damper (TLD), in the form of a rectangular tank partially filled with water, is installed within the building. The tank measures $L = 10$ m by $w = 6$ m.



a) What is the frequency of the vortex shedding if we expect winds ranging up to 50 m/s. Could the associated excitation match the building eigen-frequency measured at $f_s = 0.15$ Hz.

b) As said earlier, a rectangular container will be used in the building as a tuned liquid damper. At what height the container should be filled to obtain the same natural frequency as the building.

c) As seen in the lectures, a mechanical analogy can be used to represent the effects of linear sloshing. As we are only interested in the first asymmetric mode, we will replace the liquid inside the container with two masses: m_0 a rigid mass fixed to the container and m_1 moving mass restrained with a spring of rigidity $k_1$and a dashpot with a damping c_1. Compute the value of all the said parameters.

d) Assuming the mechanical parameters of the building are $m_s = 250 \times 6$ kg, and $c_s = 500\ Ns/m$, and the aerodynamic parameter is $C_{L,osci} = 0.684$ we will model our system using the mechanical system shown in figure 1. Find the equation of motion.

e) Numerically compute the response of the system to wind blowing at 30 m/s, 37.25 and 37.5 m/s. Also compute the response of the system if the TLD was not here.

f) What advantages and disadvantages can you think of for a tuned liquid damper compared to a classic one.