

Exercises – Serie 7 – Pseudo-static instability

Exercise 1 - Lift Galloping

Electric power lines sometime experience low-frequency and high-amplitude vertical oscillations during winter storms when the line conductor becomes covered with ice. Indeed, in the presence of wind, this ice can induce aerodynamic lift and drag forces that result in a gallop that can cause structural damage to the power line. We consider a system (ice + power line) of total mass m and denote \mathbf{D} as the drag force and \mathbf{L} the lift force acting on it. The system is constrained to vertical motion y and restrained by a spring of constant k . A is the projected area of the system on a plane normal to the flow and ρ is the air density. The effect of gravity is neglected.

Hint: consider small angles α only and perform a Taylor expansion of the aerodynamic lift and drag coefficients around $\alpha = 0$.

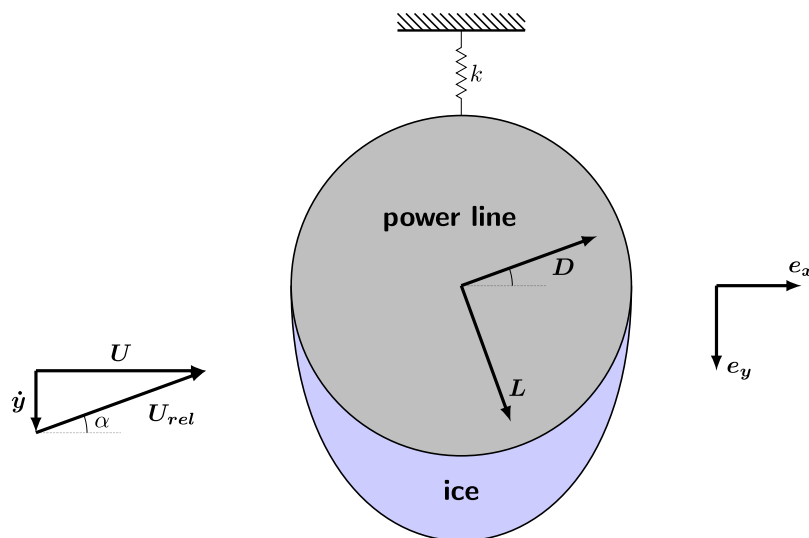


Figure 1: Iced power line.

- Assuming pseudo-static aerodynamics, determine the equation of motion.
- Find the eigenvalues of the system and show that the solution becomes unstable under the galloping condition $(C_{L,\alpha} - C_{D0}) < 0$
- Under galloping condition, is the natural frequency of the damped system higher or lower than the one in the no-flow case?
- What shapes are subject to the galloping condition? Can you think about another condition for a given shape.