Problem C3.4. Heaving and Pitching Airfoil in Wake

Overview
This problem is aimed at testing the accuracy and performance of high-order flow solvers for problems with deforming domains. An oscillating cylinder produces vortices that interact with an airfoil performing a typical flapping motion. The time histories of the drag coefficient on both the cylinder and on the airfoil are used as metrics, and two test cases corresponding to different stream-wise positions of the airfoil are studied.

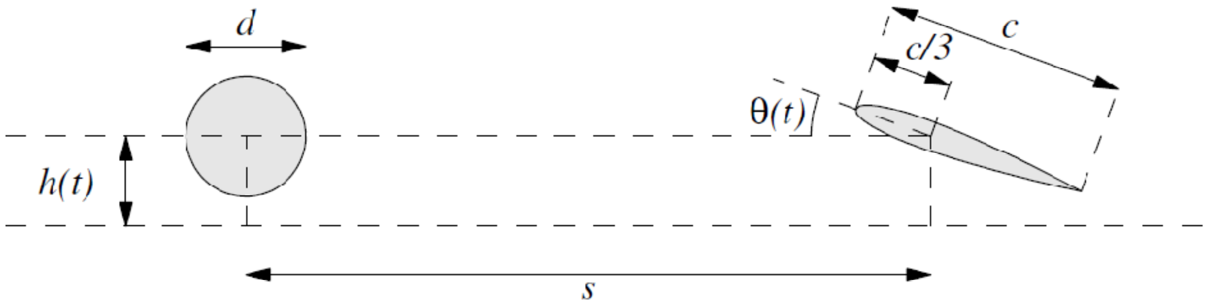
Governing Equations
The governing equations for this problem are the 2D compressible Navier-Stokes equations with a constant ratio of specific heats equal to 1.4 and a Prandtl number of 0.72.

Flow Conditions
The free-stream has a mach number (M_∞) of 0.2 and an angle of attack (α) of 0°. The Reynolds number based on the chord of the airfoil is 1000 (or, equivalently, 500 based on the diameter of the cylinder).

Geometry
The geometry consists of a cylinder of diameter $d = 0.5$ centered at the origin, and a NACA0012 airfoil with chord length $c = 1$ positioned downstream from the cylinder. The geometry is given by the modification of the x^4 coefficient to give zero trailing edge thickness:

$$y = \pm 0.6(0.2969\sqrt{x} - 0.1260x - 0.3516x^2 + 0.2843x^3 - 0.1036x^4, \quad x = [0,1]$$

The center of the cylinder and the 1/3 chord of the airfoil are separated by a distance s. Both bodies are heaving in an oscillating motion $h(t) = A\sin\omega t$, where $A = 0.25$ and $\omega = 2\pi \cdot 0.2$. In addition, the airfoil it pitching about its 1/3 chord by an angle $\theta(t) = a\sin(\omega t + \varphi)$, where the amplitude $a = \pi/6$ and the phase shift $\varphi = \pi/2$.



Requirements
1. Perform the indicated simulation to an elapsed time of 100 time units (or 20 periods), for the two test cases **(a)** $s = 3.76$ and **(b)** $s = 3.5$. Maintain a time history of the drag coefficients on the cylinder and on the airfoil, and calculate the time-averaged drag coefficients for the last (10^{th}) period only. Perform a grid/timestep convergence study to get the time-averaged values accurate to within 1 drag count. Record the work units.

2. Provide the work units, the converged time history of lift and drag on the wing, *nDOF*s in the solution, and the distance to the far field boundary for each case. Submit this data to the workshop.