Waves generated by a submerged hydrofoil

Handed out: **November 30**
Data Results Due: **Monday, December 10, 8:00AM (strict deadline)**
Report Due: **Monday, December 17, 5:00PM (strict deadline)**

For your final project you are to solve the URANS equations to predict the waves generated by a steadily moving hydrofoil beneath the water surface. The `interFoam` solver uses the VOF method to capture the interface between two fluids. You will compare your results with published experimental measurements. Our `ctools` website has two papers by Prof. James Duncan who performed the experiments. I am also providing a paper, by Roberto Muscari and Andrea Di Mascio, that contains numerical results for the same experiments. This should help you understand what you should expect in terms of accuracy of your comparison. The experiments have been the source of many numerical validation studies, so if you search online, you can easily find other references that might be of interest to you.

The hydrofoil case can be described by the Froude number and Reynolds number, defined on the airfoil chord $F = U/\sqrt{gc}$, $R = Uc/\nu$, where U is the free-stream velocity, c is the chord, g is gravity, and ν is the kinematic viscosity of water. Other important parameters are the angle of attack, α, and the vertical distance from the mid-chord to the bottom of the tank h, and the vertical distance from the mid-chord to the calm-water surface d. You are to perform simulations for two cases, one that has no breaking, and the second with strong breaking. The parameters describing the cases are listed in Table 1.

Generate the mesh using Pointwise. (Or you may try snappyHexMesh.) I suggest using a tutorial case for a starting point. You should select the discretization schemes based on the previous homework that you have completed for the class.

Data Results for December 10: You are asked to provide the numerical results of the most accurate prediction you can make for Case 1 by the start of the day on December 10. We will compare and discuss the results in our final class on that day. You must submit a text file with two columns of data: x/c and y/c, where x and y are points on the free-surface, with $x = 0$ at mid chord, and $y = 0$ in the calm-free-surface plane. Positive x is downstream, and positive y is upwards. The name of the text file should have the format 'aaaa.txt', where you may use any four digit prefix that is a confidential identifier for your submission. The submission of your results will constitute 20% of your grade on the project.

Final Report: Your final report is due December 17. For the report, everyone is required to describe the process that was followed to generate your results. Also, you must compare your CFD predictions with the published experimental results. I want you to provide the most accurate results that you are capable of obtaining. Your report is limited to 6 pages. Please be thorough in your write-up.

Parameter	Case 1	Case 2
F	0.567	0.567
R	1.624×10^5	1.624×10^5
α deg	5	5
h/c	0.862	0.862
d/c	1.034	0.783

Finally, for your report, you should select one of the following topics to investigate and include in your write-up. It is important that you clearly describe the extra work that you do, and that you generate results that demonstrate your theoretical understanding of the topic that you chose.

(1) Discuss and test different discretization schemes for convection.
(2) Discuss and test the suitability of the turbulence model. You could test a low-Re number model, or test a different wall function model. There is a wall function for the Spalart-Allmaras model, and the standard $k-\omega$ model. Also, you could examine different freestream values of the turbulence quantities.
(3) Scalability. Test how the solver scales on different numbers of processors. This should be done for the conjugate-gradient and the GAMG linear-system solvers. You could test the same grid on a different number of processors, or grids with differing numbers of points on the same number of processors. Note that you don't need to run for a long time when doing scalability study.

The grade for your final project will be assigned using the following points breakdown: 20% data submission on December 10, 20% format, 20% extra topic, 40% discussion of results and work.