**AEE 342: Aerodynamics, Project 1b – Analysis of Symmetric Airfoils**

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In the study of fluid flows, it is of vital importance to perform detailed and thoughtful analysis of a fluids behavior as it interacts with an object. Such analyses may be simulated through mathematical modeling with computational tools. However, these tools are of little use if mathematical models cannot be constructed to reflect situations and interactions likely to be encountered in real life. That being the case, the problem under investigation demands precisely such modelling of a NACA 0015 airfoil and the subsequent analysis of the flow behavior around it. Fundamental to the generation of these flow conditions is the notion of a source or a sink. These terms, respectively, refer to points with either a very high velocity potential or a very low one. It is this way that sources and sinks appear to ‘deflect’ or ‘attract’ local flow depending on their strengths. With careful manipulation of these points, their positions, and their strengths, an increasingly precise representation of flow past an airfoil may be modelled. It is the convergence of this representation on expected, experimental results that lies at the crux of this investigation.

The flow being studied is defined by a flowfield given by the general system

where is the component of the velocity field, and is the component. This the general form of a 2 dimensional velocity field with sources/sinks advancing with iterator . and are coordinates of a point for which the velocity is being evaluated, while and are the coordinates of a particular source/sink. These locations are placed appropriately on the x-axis (for a symmetric airfoil) and between 0 and 1 (for the convenience of having unit chord) by defining

The relevant area is centered by defining the bounds of the velocity field as

An airfoil is defined for analysis, the equation of which is given by the NACA thickness distribution equation

where thickness for a NACA 0015 airfoil is . This is used to generate the airfoil’s surface. In order to determine the strengths of the sources/sinks, the stream function must be set equal to zero at the airfoil’s surface. This ensures that there is no flow through the airfoil boundary. can be found by integrating the equations of the velocity field, yielding

By creating a linear system containing such equations for each source/sink, the value of each source/sink may be found. With this information, the flow behavior around the NACA 0015 airfoil can successfully be modelled. The behavior of this airfoil can then be predicted by computing the pressure coefficient distribution along its chord, which is given by

where are pressure, density, and velocity, respectively. The value of is evaluated at each value along the airfoil in order to find a distribution in order to compare to NACA experimental table values. The deviation of the simulated airfoil’s behavior from that of the real airfoil is indicative of how successful the model is and whether additional refinement is necessary. This deviation is determined by calculating the root mean square error of the calculated values of against values interpolated from a table of NACA values. This error is given by

Finally, all that remains is to repeat calculations for a range of values of the number is sources/sinks and determine the error associated with each. Namely, it is critical to determine whether the solution converges with more sources/sinks. Then, depending on the requirements of the specific problem, the accuracy of the simulation can be set within a reasonable range by following this convergence.