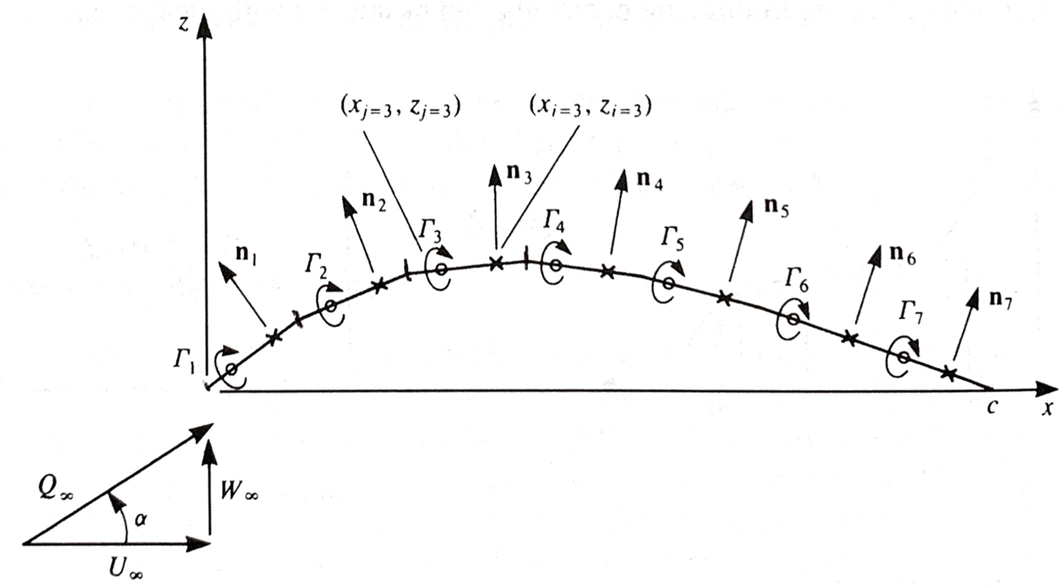
Assignment 1: Potential flow over a thin airfoil

Academic year: 2023-2024



Requirements

- Personal / group task: personal or group (max. 2 persons)
- Minimum / Maximum number of pages: 6 / 10 (excluding: Title page, program listing, etc.)
- Font size: 10 - 12

Introduction

For the analysis of airfoils, it is essential to obtain the velocity and the pressure distribution over the surface. Based on this the lift and the pitching moment can be obtained while in a potential flow approach. The drag remains zero due to the absence of viscosity. The drag of the airfoil can be determined if also the development of the boundary is calculated. This requires an interaction between the inviscid (potential flow) and viscous (boundary layer) calculation which is outside the scope of this assignment.

To get a basic understanding of the capabilities and limitations of potential flow calculations on airfoils this assignment is aimed at developing a very simple flat panel model that is capable of predicting the characteristics of thin airfoils. You are requested to write a program that calculates the potential flow over 2-dimensional airfoils with zero thickness (according to the so-called "thin airfoil theory").

Tasks

Write a clear and concise program that is able to calculate the pressure distribution (ΔC_p vs. x/c) and the lift coefficient of **a planar airfoil** with **zero thickness** according to a numerical approximation of the Thin Airfoil Theory. You may use the programming language/environment of your preference (MATLAB, Python or Fortran).

Feel free to apply **Artificial Intelligence** (AI) like ChatGPT to write your program (make sure you check the correct working of the program). In any case make sure to add a flow diagram as well as enough comment lines to describe the working principle. Add a listing at the end of the assignment.

The solver should be based on a discrete vortex distribution over a paneled **uncambered** airfoil. For the details on the theory please refer to standard textbooks like:

- J. Katz and A. Plotkin, "Low-Speed Aerodynamics" (Cambridge Aerospace Series) (section 5.2)
- J.J. Bertin, "Aerodynamics for Engineers"
- A.M. Kuethe and C. Chow, "Foundations of Aerodynamics: Bases of Aerodynamic Design"

Tasks

Once the program has been established perform the following tasks:

1. Present and shortly discuss the flow diagram of your solver. What essential steps are taken to arrive at the pressure distributions and the lift coefficient? Also discuss what key equations and parameters are utilized.

2. Check the correct working of the program by comparing the calculation results with that found in open literature. Plot one or more typical pressure distributions in the same figure for easy comparison. Discuss the results.

3. **Add the listing of the program at the end of the report**. Make sure to add **comments** in the code that explain the various steps. Without the comments that explain the flow of the program the assignment will not be accepted.

4. Discuss shortly what changes are to be expected w.r.t. the lift coefficient and the pitching moment coefficient versus angle of attack when a cambered airfoil would have been modeled.

5. Sketch (hand sketch, add your signature and date to it) and discuss this differences that would be found if the pressure distribution is compared to the one of an airfoil with finite thickness.

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