MECH 539 Computational Aerodynamics

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1 Assignment 4

1.1 Question 1

In this question, I plot the coefficient of Pressure above and below the airfoil and investigate the type of airflow. The following graph was obtained: NOTE: The direction of the y-axis is reversed.

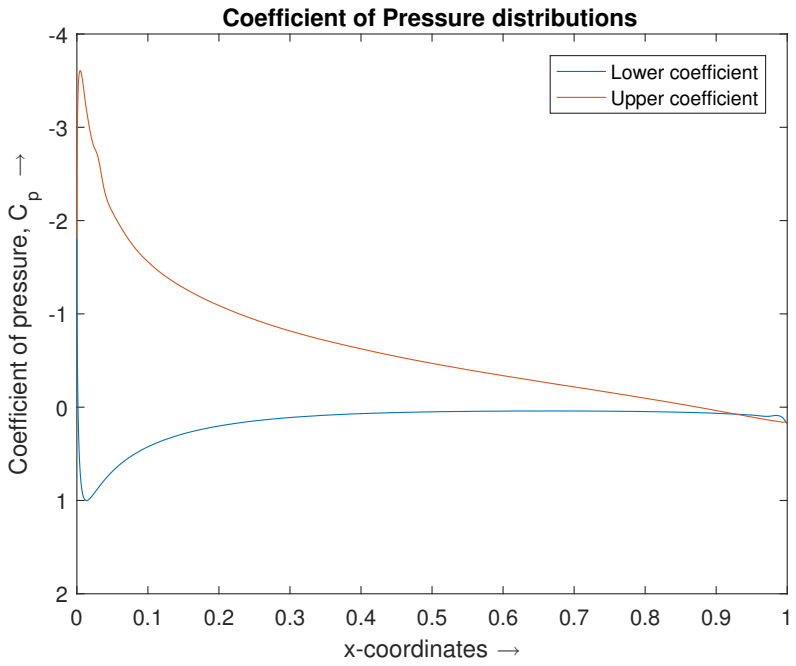

Figure 1: Variation of Pressure Distribution

From the graph, it clearly visible that the flow below the airfoil is subsonic throughout the airfoil, whereas there is a sudden drop in the coefficient

of pressure,C_p on top of the airfoil indicating that there is a shock wave/flow separation at the leading edge of the airfoil.

1.2 Question 2

In this question, I evaluate the variation of the skin friction coefficient, C_f over the top and bottom of the airfoil and plot it against the x-axis. The following graph was obtained:

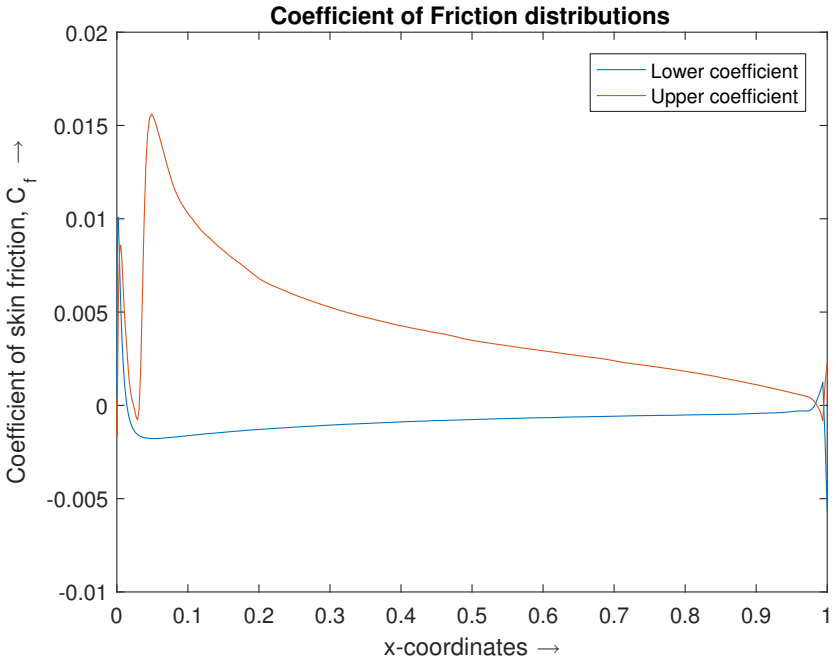

Figure 2: Variation of Skin friction Coefficient

1.3 Question 3

The aerodynamic performance of the airfoil is investigated in this question. The following values were obtained for the coefficient of lift (C_l), coefficient of drag due to pressure (C_{dp}), coefficient of drag due to friction (C_{df}) and coefficient of drag (C_d). The results are tabulated below:

C_l	C_{dp}	C_{dv}	C_d
0.80894577600108	0.00492109968709653	0.00511563219232762	0.0100367318794241

The experimental data for the airfoil was obtained from a textbook called Theory of Wing sections which was written by Ira H Abott and Abert E Von Doenhoff. The following data was obtained from the graphs:

C_l	C_d
0.85	0.11

We can see that the results obtained from the experiment and the result obtained from the computation are really close, hence our results are valid.

1.4 Question 4

In this question we investigate the boundary layer. The flow initially is laminar but then separates as we can see from the plot of the coefficient of friction and the flow then becomes turbulent. The following graphs where obtained for the region with laminar flow and the region with turbulent flow: NOTE: the y-axis is taken in log.

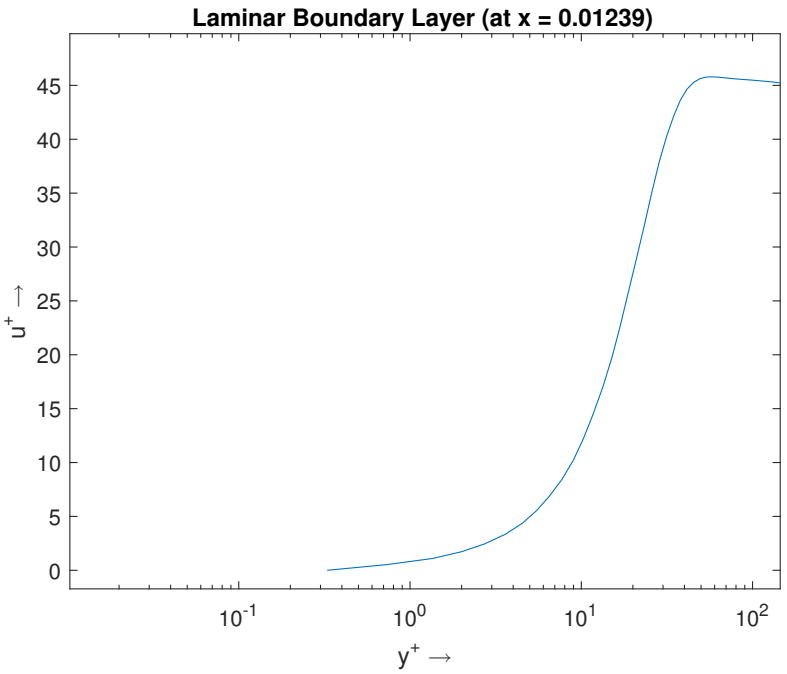

Figure 3: Velocity Profile in Laminar region

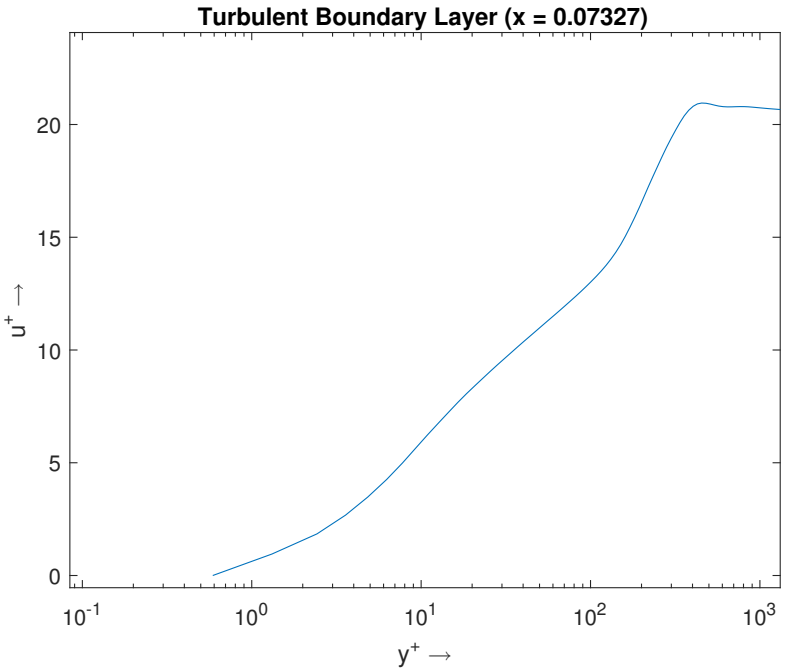

Figure 4: Velocity Profile in Turbulent region

1.5 Question 5

In this question we were asked to plot the $u+$ vs $y+$ graph when $x = 0.5$ and also then plot the analytical solutions in the viscous sub-layer and the log-law region of the inner boundary layer. The following graph was obtained:

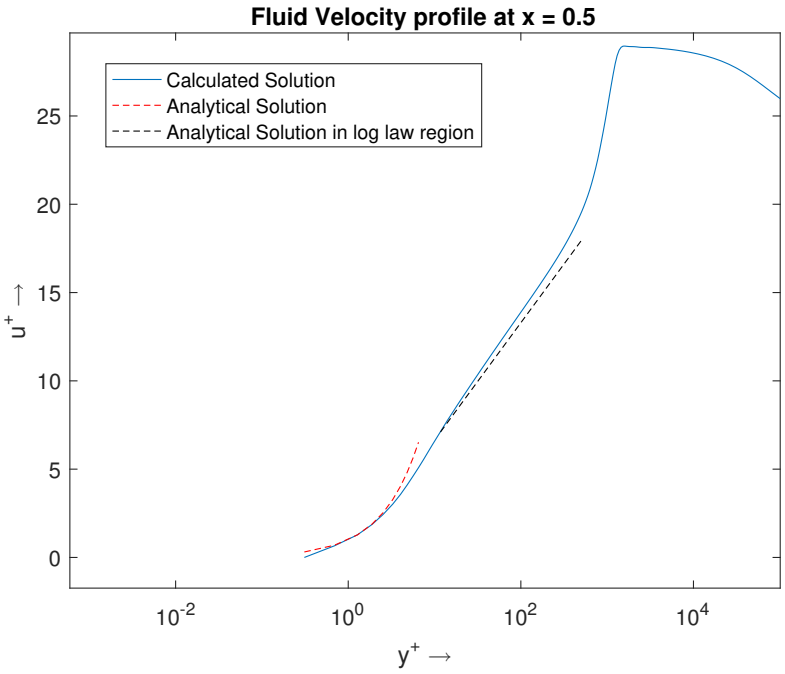

Figure 5: Fluid Velocity profile at $x = 0.5$

1.6 Question 6

In this question I investigate the momentum deficit in the wake behind the airfoil by plotting the fluid velocity profile at quarter chord, half chord, 1 chord and 2 chord behind the airfoil. The above plot was obtained.

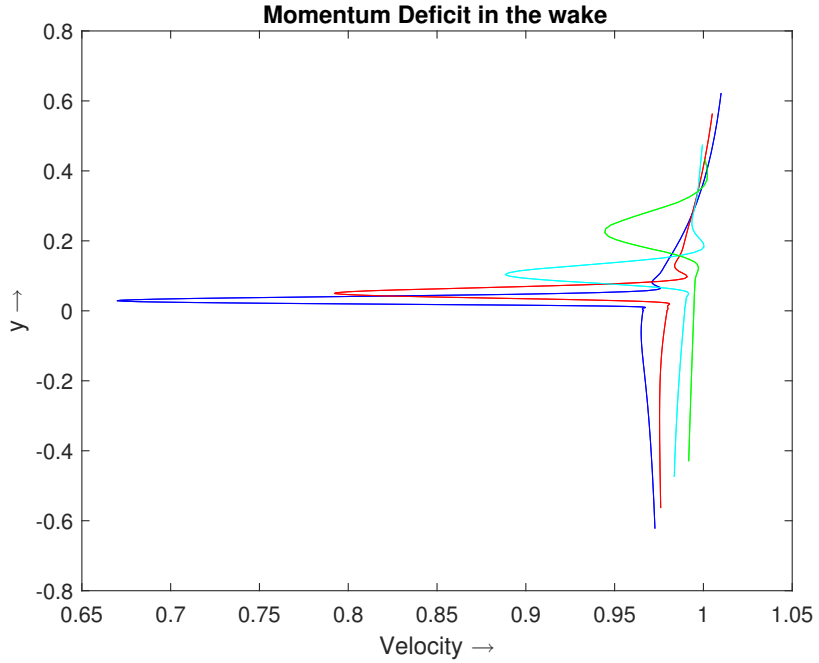

Figure 6: Fluid Velocity Profile

NOTE: There is a problem with my MATLAB as it wasn't allowing me to create the legend for this graph for some reason, the colors are as follows: Blue is a quarter chord behind the airfoil, red is half chord behind the airfoil, cyan is 1 chord behind the airfoil and green is 2 chords behind the airfoil.
The most momentum deficit occurs at a quarter chord behind the airfoil, and the deficit decreases as we move further back from the airfoil, as it is clearly seen from the graph above.