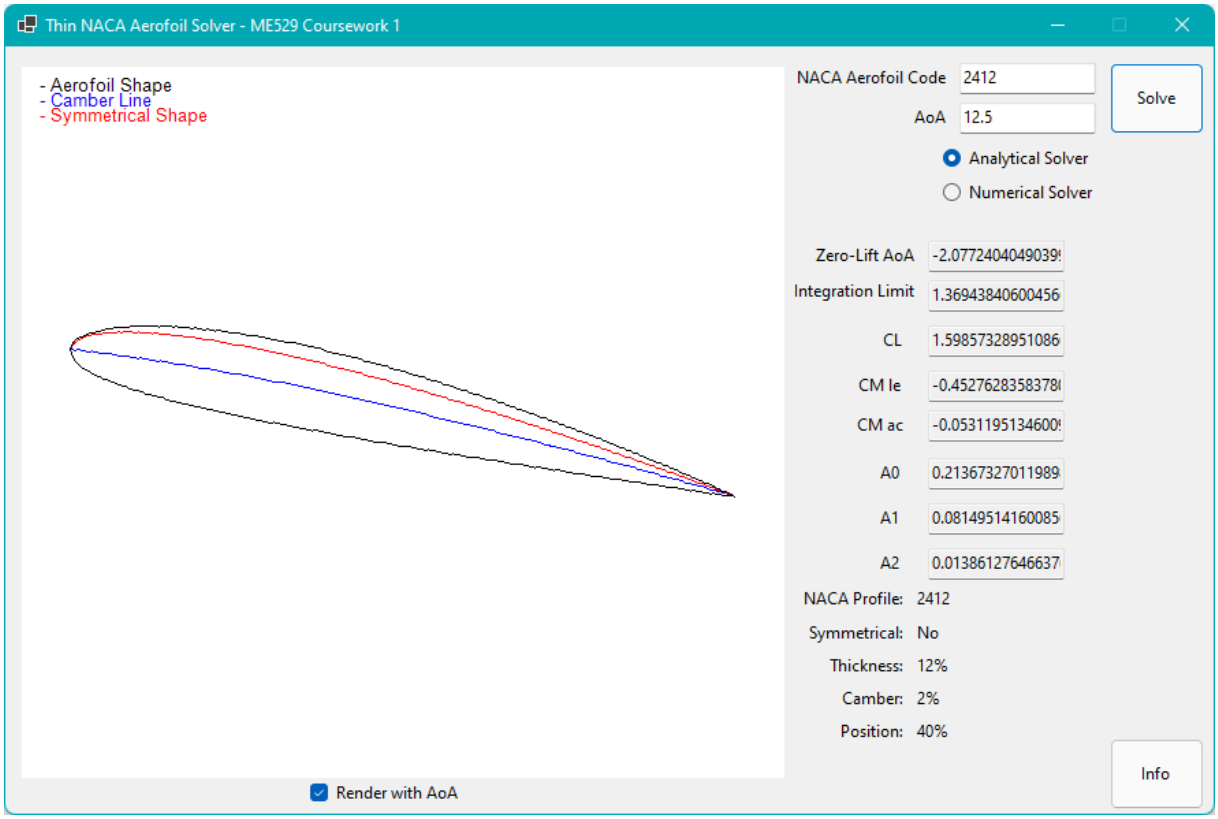

ME529 Aerodynamics in C – Coursework #1 Report

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1 INTRODUCTION

This report details the testing and validation of the software written for coursework 1 of ME529 – Aerodynamics in C. In order to fully test the results from the program, a set of testing conditions were used to cover an appropriate range of the possible input value conditions, the testing input set is listed below.

4-digit NACA code	4412	2412
5-digit NACA code	23012	24112
Angles of Attack	0°	2°

Table 1 - Software Input Testing Values

The above conditions were tested on both the analytical and numerical solving routines. A value of 6 sub-intervals was used consistently for the numerical method. As the values for the pitching moment about the aerodynamic centre (CM_{ac}) and the lift coefficient (C_L) are calculated from the thin aerofoil theory coefficients A0, A1 and A2, only the CM_{ac} and C_L parameters were used for testing, as this ensures the prerequisite parameters are also correct.

2 RESULTS FROM EXPERIMENTAL DATA

Real world experimental data for the NACA profile 24112 tested was not readily available and therefore is omitted from the experimental data results. Experimental data for the 4412 and 2412 was found in the appendix of the textbook “Aerodynamics and Aircraft Performance”[1], and the 23012 data was provided by Dr. Stickland, as resource material[2]. The appropriate data is correlated and presented below.

Aerofoil	C_L (0°)	CM_{ac} (0°)	C_L (2°)	CM_{ac} (2°)
4412	0.41	-0.084	0.66	-0.083
2412	0.26	-0.042	0.42	-0.038
23012	0.12	-0.012	0.34	-0.005

Table 2 - Experiment Data Results

3 RESULTS FROM WRITTEN COURSEWORK SOFTWARE

Below is a table of the results acquired for the above input conditions, from the software written for the completion of this project.

Aerofoil	**Analytical:**	C_L	CM_{ac}	**Numerical:**	C_L	CM_{ac}
4412		0.455590	-0.106239		0.455590	-0.106237
2412		0.227795	-0.053120		0.227795	-0.053118
23012		0.119925	-0.012835		0.119908	-0.012840
24112		0.093542	0.000058		0.093521	0.000055

Table 3 - Angle of attack = 0° Results

Aerofoil	**Analytical:**	C_L	CM_{ac}	**Numerical:**	C_L	CM_{ac}
4412		0.674914	-0.106239		0.674914	-0.106237
2412		0.447119	-0.053120		0.447119	-0.053118
23012		0.339249	-0.012836		0.339233	-0.012841
24112		0.312867	0.000058		0.312846	0.000057

Table 4 - Angle of attack = 2° Results

4 CONCLUSION

A comparison showing the differences between the experimental results and the software results is shown the table below.

Aerofoil	Analytical:	C_L	CM_{ac}	Numerical:	C_L	CM_{ac}
4412		0.04559	-0.022239		0.04559	-0.022237
2412		-0.032205	-0.01112		-0.032205	-0.011118
23012		-7.5E-05	-0.000835		-9.2E-05	-0.00084

Table 5 - Difference Between Experimental and Software Results - Angle of attack = 0°

Aerofoil	Analytical:	C_L	CM_{ac}	Numerical:	C_L	CM_{ac}
4412		0.014914	-0.023239		0.014914	-0.023237
2412		0.027119	-0.01512		0.027119	-0.015118
23012		-0.000751	-0.007836		-0.000767	-0.007841

Table 6 - Difference Between Experimental and Software Results - Angle of attack = 2°

It can be seen from the comparison above that the experimental data does differ somewhat from the software data in terms of parameter value, however the trends and relationships in the data are the same, and the relative difference is not huge, however it is not small enough to be considered within a margin of error, this is most likely a result of the thin aerofoil theory approximation. There is little to no difference between the analytical and numerical results, showing that 8 sub-intervals are more than appropriate for the numerical Simpson's rule method. Overall, the results from the software can be considered accurate in terms of calculation, and of course depending on the application, relatively accurate in terms of parameter results. Notably, the software seems to agree almost exactly with the experimental data for the lift coefficient of the NACA 23012 5-digit aerofoil. Also, increasing the number of sub-divisions pushes the results increasingly closer to the analytical results as the numerical integration approximation becomes increasingly more accurate.

The software as tested against the reference software given in the class resource on MyPlace, and the results were found to coincide exactly, inferring that the calculation routines are correct.

5 REFERENCES

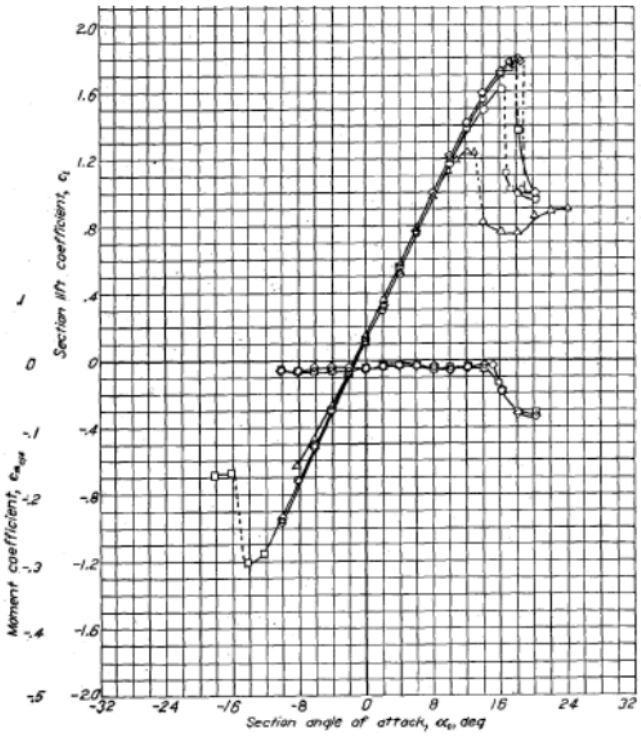
[1] J. F. Marchman, A. Walz, K. Grey, and Virginia Polytechnic Institute and State University. University Libraries, *Aerodynamics and aircraft performance*. 2004.

[2] M. Stickland, "NACA 5-digit Airfoil Data." University of Strathclyde - MyPlace, 2022.

6 APPENDICES

Appendix 1 – NACA 23012 Experimental Data[2]

NACA 23012



Appendix 2 – NACA 2412 (left) and NACA 4412 (right) Experimental data[1]