Portfolio 1

2022 / 2023

Name:	
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Report Title	
Submission Date	

Instructions for using this document:

The DO's:

- ✓ See the main Course Work (CW) brief for details of the Lab report
- ✓ Be as succinct and concise as possible in your responses.
- ✓ Remember to justify your answers; simple statements without justification are not credible.
- ✓ You are allowed to change the size of the textbox and modify this template.
- ✓ Using of this template is recommended

The DO NOT's:

- Exceed 2000 words within your report.

Use of this template is optional, and you can use it as guideline only to structure your report.

Solid mechanics lab report

1. Abstract 5%

Please enter your response in the below text box:

The deflection of a cantilever beam was subjected to a series of different loads, each of which was applied at a different location along the beam's length, and the results of this experiment were measured. Aluminum and stainless steel, both quite different materials, were used to make the beams that were employed. The theoretical section also includes a discussion of the equation that describes the beam's deflection. A deflection gauge was utilised in order to get accurate readings of the experiment's levels of deflection. Theoretical and experimental findings were compared in order to validate the equations that were utilised in the process of predicting the deflection, and the percentage of error was also determined. At last, graphs were created to show the relationship between deflections and the loads that were applied.

2. Introduction 10%

Please enter your response in the below text box:

Remember to include citations whenever needed

The bending of a beam was the focus of this experiment, which was designed to measure that parameter. Cantilever beams are utilised in numerous building applications, the most notable of which being cantilever bridge, cantilever cranes, cantilever shelves, and cantilever balconies. Cantilever bridges typically have their cantilever beams constructed in pairs; each pair of cantilever beams is then tasked with the responsibility of supporting one end of such a central section. Cantilever truss bridges are one type of bridge, and one example of these is the Forth Bridge in Scotland. Cantilevers are also used in the design of fixed-wing aircraft, which is another application for this design element. Therefore, cantilever beams find application in a wide variety of different areas of life. In order to design beams effectively, it is required to ascertain both the maximum deflection that the beam would experience when it is loaded and the strength of the beam itself.

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3. Experimental Procedures 15%

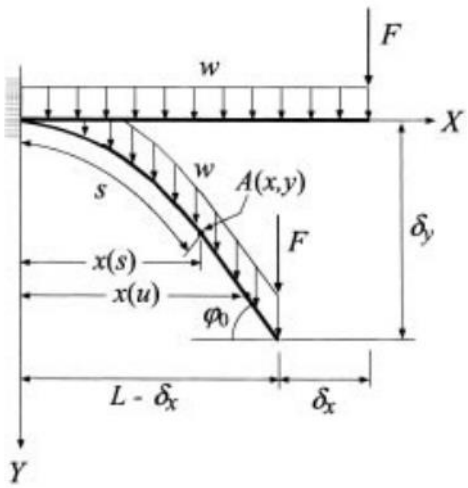
Please enter your response in the below text box (please use pullet points):

- In the first step of the process, the least count of the deflection gauge was determined by applying the following formula: Least Count = Smallest division on main scale / No. of divisions on those other scales = 0.2/200 mm = 0.001mm

- A support was used to clamp the beam in place. The beam was marked at three distinct locations, as well as the gauge was fastened to the beam at a single point that was located in the middle of such beam's breadth.
- Different loads from 0.29N to 1.45N applied on the hanger.
- The initial value of the beam's deflection was measured with the hanger still attached to the beam. The hanger was loaded with 1 newton of force, and the resulting reading on the gauge was recorded. The term "deflection" refers to the difference between the first value but this value.
- At each load level, the value of the deflection was measured, and a 50-g increment was added to the load.

- The experiment was carried out multiple times using various predetermined values of x. (placing gauge at different distances from the load point).
- A Vernier calliper was utilised in order to acquire accurate readings of the cantilever beam's dimensions.

For the purpose of this task, you may include a maximum of 2 illustrations; use the boxes below to define these.



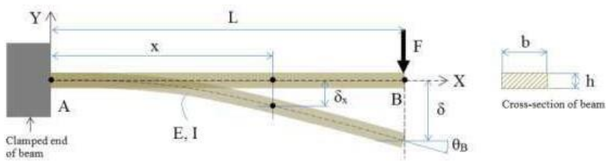


Figure 1 (above)	Cantilever beam applied force diagram	Figure 2 (above)	Beam deflection

4. Results 25%

Please enter your comments relating to the results description the below text box and provide sample of hand calculation:

Applying Hooke's Law will allow one to derive stresses from previously measured strains. In order to have a better understanding of and be able to defend the results of your measurements, you will need to do an analytical calculation to determine the deflection of a cantilever beam under different loads applied to the free end as well as the stress at the position of the strain gauge.

$$\sigma = \varepsilon E$$

Where represents the normal stress, M represents the bending moment, y represents the distance to the extreme edge (h/2 for the rectangular cross-section), and I represents the second moment of area for the beam. The formula for a cross-section of a rectangle looks like this $\frac{bh^3}{12}$

The calculations are

$$M = -F(L - x)$$

The following formula can be used to determine the cantilever beam's deflection (), which is dependent on the load (F), the beam's modulus of elasticity (E), the beam's moment of inertia, and the beam's length

$$\delta = \frac{\mathrm{F}x^2}{6El}(3\mathrm{L} - \mathrm{x})$$

For the purpose of this task, you may include a maximum of eight illustrations; use the boxes below to define these.

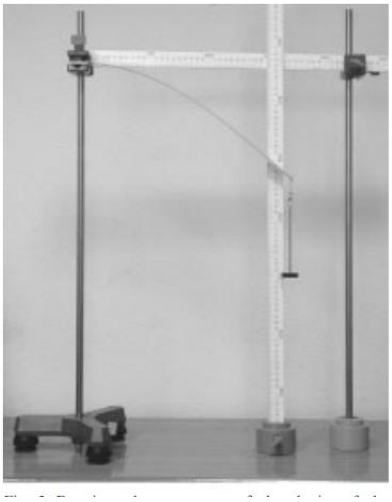


Figure 3 (above)	Insert caption here	Figure 4 (above)	Insert caption here

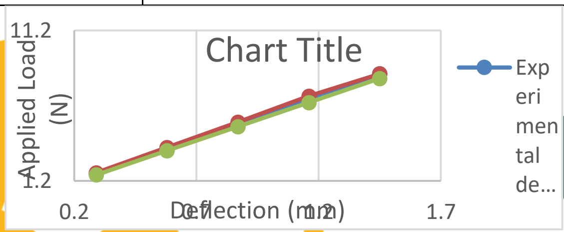
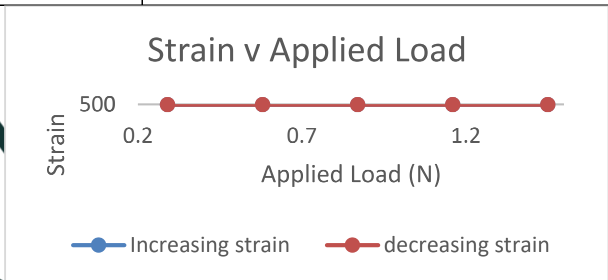

		

Figure 5 (above)	Deflection of Beam	Figure 6 (above)	Strain analysis

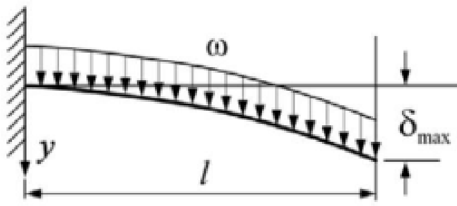


Figure 7(above)	Beam Deflection

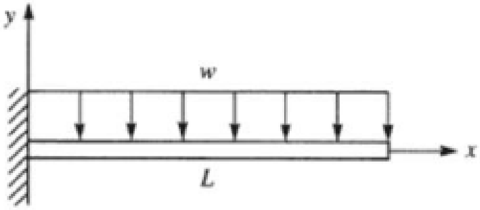


Figure 8 (above)	Uniformly distributed force

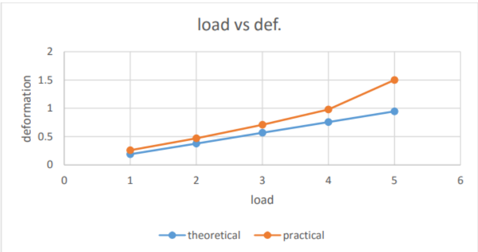


Figure 9 (above)	Load Vs Deflection

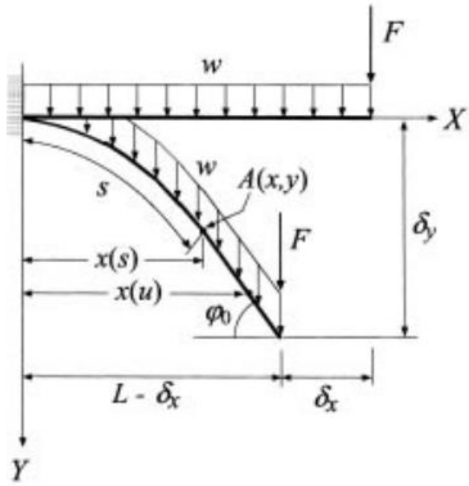


Figure 10 (above)	Applied forces cause deflection

Please insert the result table below and add caption:

applied load (N)	Experimental deflection (mm) increasing	Experimental deflection (mm) decrising	calculated deflection	Increasing strain	decreasing strain
0.29	1.66	1.73	1.6	45	46
0.58	3.3	3.42	3.2	89	91
0.87	4.99	5.1	4.8	135	137
1.16	6.65	6.83	6.4	179	183
1.45	8.31	8.31	8	223	223

applied load (N)	Increasing strain	decreasing strain
0.29	45	46
0.58	89	91
0.87	135	137
1.16	179	183
1.45	223	223

5. Discussions 35%

Please write your discussion here. Please discuss errors and how it can affect the results. Also, discuss how the result can be validated with other methods and comments on applicability of this Lab in real world. Compare your results to associated literature and. Include citations whenever needed.

Determining the amount of deflection that two cantilever beams would have underwent was the objective of this experiment. It is clear from the findings that the calculated values and the measured values do not match up, but it is also clear that the measured values are in perfect agreement with one another, which indicates that there is a trend in the deflection. It's possible that the deflection gauge has some kind of systematic inaccuracy, which would account for the large percentage of errors. The following are some more potential causes of errors that should be considered: a. When we derive the formula for deflection, we make the assumption that the beam is linear elastic, prismatic, and so on. This is the ideal case. In the real world, such presumptions are proven to be incorrect. b. The load in the hanger was not positioned correctly, despite the fact that the theory states that the load is concentrated; this is not in agreement with our case. In addition to this, we do not position the load precisely at the extremity of the beam. c. The error could be due to human error, such as making a mistake when recording the reading from the deflection gauge and the Vernier callipers. When compared to the deflection caused by a beam made of stainless steel, the amount of deflection caused by an aluminium beam is greater. The reason for this is that the Young's Modulus value of steel is higher than that of aluminium. In spite of the mistakes, it is clear from both the overall results and the graphs that the goal has been successfully accomplished and served its intended purpose.

6. Conclusion 5%

Please write report conclusion, recommendation, and future work below

We have gained a significant amount of knowledge regarding how the bending of a beam is determined by the load on the beam, the material qualities of the beam, the cross section of the beam, and the manner in which the beam is supported. As a starting point for comprehending the static deformations of much more sophisticated structures, we make use of the static beam equation as well as the principles that we have investigated. When compared to brass, aluminium has a greater degree of deflection.

7. References 5%

Please list your references here.

1. .Kamentser B. (1994) *New Generation of Strain Gauge Accelerometers.* Paper no. 942151. Aerotech '94, October 3-6 1994 Los Angeles. Society of Automotive Engineers

2. Kato Y., Sumi C. (1993) *The Film Strain Gauge Sensors for Automotive Applications.* Paper no. 930356. International Congress and Exposition, March 1-5 1993, Detroit. Society of Automotive Engineers

3. Window A.L. (ed.) (1989) *Strain Gauge Technology.* Barking: Elsevier Science Publishers LTD

4. Wurst R. L. (2004) *Engine Torque Measurements Using Telemetry.* Paper no. 2004-01-2679. SAE Commercial Vehicle Engineering Congress and Exhibition, October 26-2 2004, Chicago. Society of Automotive Engineers

5. Vishay Micro-Measurements (2005) *The Three-Wire Quarter-Bridge Circuit*

8. Appendix

Please insert any appendix here (if needed)

Thermofluids lab report

9. Abstract 5%

Please enter your response in the below text box:

In this experiment, the amount of lift generated by a NACA 2412 at different angles of attack was measured by changing the angle of attack in a wind tunnel. At the crucial angle of attack, the lift coefficient was shown to increase linearly up to a maximum before rapidly decreasing. After determining that increasing the angle of attack at which stall occurs was possible, a leading-edge slat was added to the aerofoil. Over the course of the experiment, pressure arrow diagrams were made on a variety of aerofoils, including those with and without leading-edge slats. Because of this, we now have a better grasp on the causes of stall and the consequences of installing a slat in the leading edge of an aerofoil. A similar experiment conducted by NACA in the 20th century at a higher Reynolds number served as a comparison.

10. Introduction 10%

Please enter your response in the below text box:

Remember to include citations whenever needed

Theoretical considerations as well as practical applications of wind tunnel testing in the aerospace industry are the focus of this assignment. This assignment details several distinct types of wind tunnels, as well as the benefits and drawbacks associated with each. After that comes a report on the studies that were carried out in the laboratory utilising a slow speed subsonic wind tunnel. There were two main kinds of experiments carried out. In the first experiment, wind tunnel calibrations are discussed, and vital experimental knowledge regarding calibrating the wind tunnel settings to improve the overall performance of the experiments' outcomes is shared. The NACA 2412 variable-flap aerofoil is the subject of the second experiment. Two conclusions may be drawn from the experiment regarding the boundary layer effect that was caused by adjusting the flap angle. In order to arrive at a meaningful result at the end of the Windtunnel experiment, various Flap angles are tested with a variety of different values of Velocity. The task requires the creation of graphical representations of the results in order to analyse the WindTunnel testing results and compare various sets of values in order to comprehend how it operates. To make comprehending the overall purpose of the assignment easier, it has been broken down into its component parts and duties. In addition, the assignment is a theoretical investigation of aerodynamics performed over an airfoil and represents a simulated view of an actual aircraft. In order to arrive at a conclusion and determine the outcomes, the three most important aerodynamic parameters—lift, drag, and the pitching moment coefficient—were analysed and evaluated. In addition, the findings are compared to the theoretical equations, and the reasoning that went into the findings is broken down in detail so that the reader may get a better grasp on the overall concept of each experiment.

Please enter your response in the below text box (please use pullet points):

- Using pressure tappings, the force exerted in various areas of a NACA 2412 aerofoil is determined in a wind tunnel.
- A wind tunnel has a fan installed at its far end to circulate air inside the tube. The aerofoil is installed in the test portion .
- All through the wind tunnel there isn't any work done. Just after test section due to the presence of a fan where work is being done, the formula is no longer valid.
- The NACA 2415 aerofoil is installed in the working part of a 0.3m diameter return circuit wind tunnel .
- Two-dimensional flow across the wing is achieved by using the test section walls as an end plate. The wing is also supported by two integrals spigots that pass through the bushes in the Perspex window of the test area.
- With a pointer and protractor, the angle of attack can be adjusted within a range of 30. When the wind tunnel is activated, a Pitot-Static tube is used to determine the air velocity. There are 33 pressure tappings in a single chordal plane on the wing, and this helps the programme determine the overall pressure distribution on the wing. Since the lift is mostly due to the pressure forces, the shear stress will be disregarded.
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For the purpose of this task, you may include a maximum of 2 illustrations; use the boxes below to define these.

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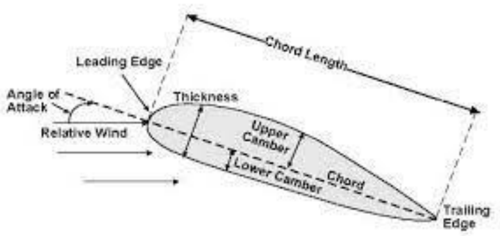
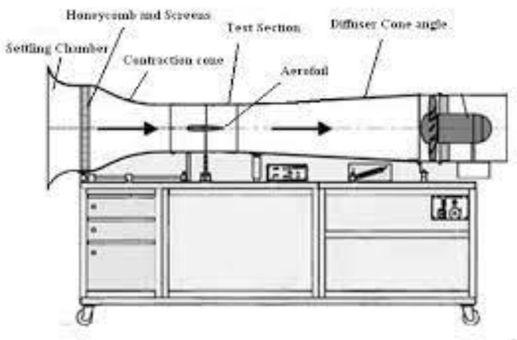
<tr><td colspan="2">
</td><td colspan="2">
</td></tr>
<tr><td>Figure 1 (above)</td><td>Areofoil drag</td><td>Figure 2 (above)</td><td>Windtunnel</td></tr>
</table>

Please enter your comments relating to the results description the below text box and provide sample of hand calculation:

It has been found that the lift coefficient is proportional to the angle of attack. Outside of the parameter range, the link breaks out. Therefore, CL grows linearly with the angle of attack because a higher angle of attack causes airflow to pass a barrier, creating a shorter path and a higher velocity. At a certain angle of attack, lift suddenly decreases; this angle is known as the critical angle of attack. The stagnation point, when the coefficient of pressure is 1, shifts farther along the lower surface as the angle of attack grows larger. In addition, a rise in lift is caused by an increase in the coefficient of negative pressure, also known as an adverse pressure gradient, on the upper surface.

When the CL is increased beyond a certain angle of attack, the lift suddenly decreases. The Boundary Layer Separation is primarily to blame for this. In the wind tunnel, a boundary layer forms as air flows over the aerofoil as a result of viscous forces between the fluid and the surface. As the angle of attack is raised, the speed of the boundary layers increases until reaching a point where the relative velocity is zero, and a zero-shear-stress is operating on it . And thus it is that a boundary layer forms. The boundary layer thickens suddenly and is then driven off by the reversed flow of the bottom surface. This leads to an increase in drag and a decrease in lift generating an Aerodynamic Stall.

Lift is measured by

$$L = \frac{1}{2}\rho V^2 A_s C_l$$

It may be argued that an aerofoil with a leading-edge slat has a higher angle of attack at which stall occurs. This is because of a supplementary air current. The secondary airflow which travels between the slat and the aerofoil injects a high momentum fluid onto the upper surface. The boundary layer is energised, with less drag and more lift, thanks to this fluid. The stall angle rises as a result. Furthermore, the angle of attack at which stalling occurs varies depending on the Reynolds number, which means the fluid or the speed circumstances. Since there is more energy in the fluid, the boundary layer is compelled to remain on the surface for a greater length of time as the Reynolds number increases. This shifts the point of separation further towards the trailing edge where drag will decrease giving a larger lift.

The drag is find by

$$D = \frac{1}{2}\rho V^2 A_s C_D$$

The Dynamic pressure is measured by

$P_d = \frac{1}{2}\rho V^2$

The disparity between the experiments and the theory can be attributed to the presence of Experimental Uncertainties.

For the purpose of this task, you may include a maximum of eight illustrations; use the boxes below to define these.

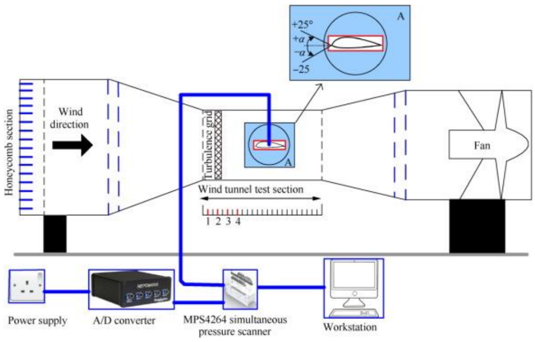


Figure 3 (above)	Windtunnel

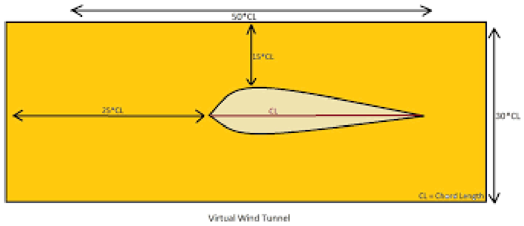


Figure 4 (above)	Aerofoil

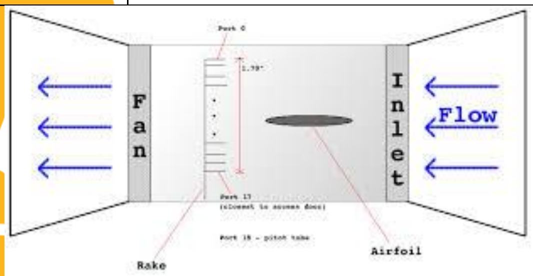


Figure 5 (above)	Wintunnel

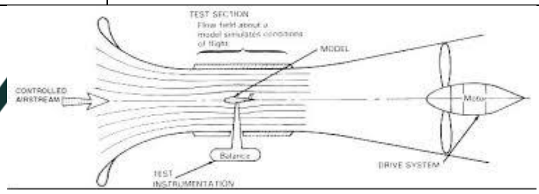


Figure 6 (above)	Winner tunnel areofoil

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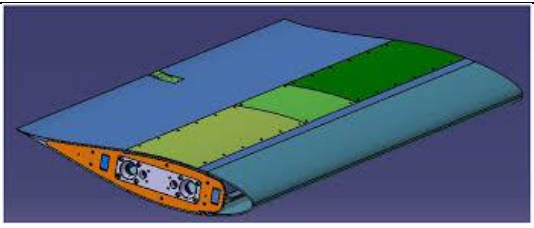
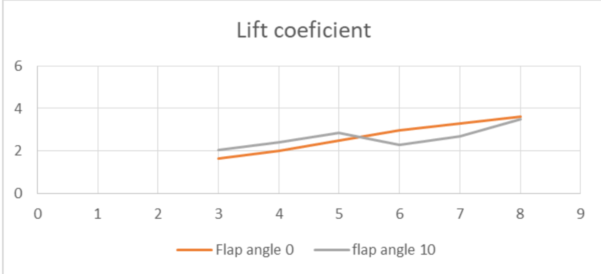
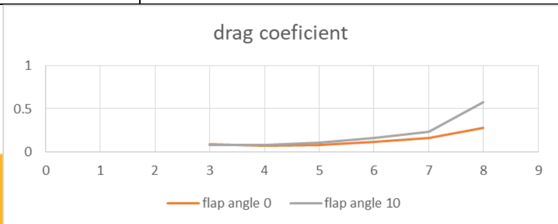
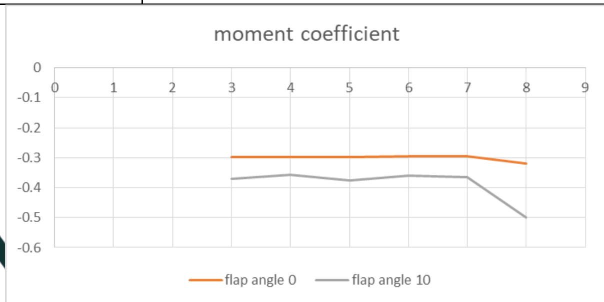
<tr><td colspan="2"></td><td colspan="2">
</td></tr>
<tr><td>Figure 7(above)</td><td>NACA2412</td><td>Figure 8 (above)</td><td>Lift Coefficent</td></tr>
<tr><td colspan="2">
</td><td colspan="2">
</td></tr>
<tr><td>Figure 9 (above)</td><td>Drag Coefficent</td><td>Figure 10 (above)</td><td>Moment coefficent</td></tr>
</table>

Please insert the result table below and add caption:

13. Discussions 35%

Please write your discussion here. Please discuss errors and how it can affect the results. Also, discuss how the result can be validated with other methods and comments on applicability of this Lab in real world. Compare your results to associated literature and. Include citations whenever needed.

The discrepancy between the experiment and theory occurred because of Experimental Uncertainties. Firstly, when aligning the angle of attack of the aerofoil utilising the spigots at the correct angles, it was challenging to align it due to the parallax effect. Secondly, there were many interpretations and different people interpreting data. Since different persons have differing precision, this resulted to considerable uncertainty. Thirdly, the programme employs the trapezium rule instead of integrating to get the pressure surrounding the aerofoil. Finally, the compression tube were long which may have altered the speed of the air.

lift coeficient

Flap angle	angle of attack	-5	0	5	10	15	20
0		1.64	2.02	2.47	2.97	3.31	3.6
10		2.05	2.42	2.87	2.3	2.68	3.5

drag coeficient

Flap angle	angle of attack	-5	0	5	10	15	20
0		0.086	0.075	0.08	0.12	0.16	0.28
10		0.08	0.08	0.111	0.158	0.23	0.58

moment coeficient

Flap angle	angle of attack	-5	0	5	10	15	20
0		-0.298	-0.298	-0.298	-0.295	-0.296	-0.32
10		-0.37	-0.357	-0.377	-0.36	-0.365	-0.5

14. Conclusion 5%

Please write report conclusion, recommendation, and future work below

Research compared aerofoil properties at varying angles of attack. At a range of Reynolds numbers, the experimental values were also compared to the NACA 2412. It also highlighted the difference in essential properties upon adding a leading-edge slat such as the increase of the angle of attack at which stall occurs. It was determined that the aerofoil had a maximum lift coefficient of 1.42 without slats and 3.5 with slats. Pressure graphs showed a steep pressure gradient at the leading edge, which gradually flattened out as it progressed along the aerofoil. In conclusion, the experiment established that the lift coefficient grows as the angle of attack increases and the Reynolds Number increases up to a specific critical angle of attack.

15. References 5%

Please list your references here.

[1] Wikipedia, " Airfoil," [Online]. Available: https://en.wikipedia.org/wiki/airfoil. [Accessed 12 October 2018].

[2] Jacobs, Eastman N.; and Pinkerton, Robert M.: Tests in the Variable-Density Wind Tunnel of Related Airfoils Having the Maximum Camber Unusually Far Forward. NACA Rep. 537, 1935.

[3] Encyclopedia Britannica. (2018). Boundary layer | fluid mechanics. [online] Available at: https://www.britannica.com/science/boundary-layer [Accessed 13 Oct. 2018].

[4] Lock G., "ME20022 Fluid Dynamics -Aerofoil Experiment," University of Bath,2018.

[5]Jacobs, Eastman N.; and Pinkerton, Robert M.: Tests in the Variable-Density Wind Tunnel of Related Airfoils Having the Maximum Camber Unusually Far Forward. NACA Rep. 537, 1935.

16. Appendix

Please insert any appendix here (if needed)

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