

ERCIYES UNIVERSITY FACULTY OF ENGINEERING
DEPARTMENT OF ENERGY SYSTEMS ENGINEERING



EXPERIMENT SHEET

EXPERIMENT TITLE

MEASUREMENT OF AERODYNAMIC FORCE COEFFICIENTS

COURSE INSTRUCTOR

INSTRUCTOR CONDUCTING THE EXPERIMENT

EXPERIMENT

GROUP:

EXPERIMENT

DATE :

SUBMISSION

DATE :

1. PURPOSE OF THE EXPERIMENT: Calculation of lift and drag forces acting on an airfoil and determination of aerodynamic force coefficients.

2. THEORY OF THE EXPERIMENT:

Measurement of Aerodynamic Force Coefficients

Force measurement systems are designed using load cells in which strain gauges are connected to form a Wheatstone bridge. Strain gauges are elements that elongate due to deformation caused by an applied force, with their electrical resistance changing in proportion to the amount of elongation. The operating principle of load cells relies on the concept that the products of the opposing resistors in the Wheatstone bridge are equal. When force is applied to the load cells, the change in length - proportional to the force - alters the resistance. This change, in turn, alters the output voltage. By measuring this voltage change and converting it into electrical signals, the force is quantified using a data acquisition card and software. Additional circuits and systems are employed to eliminate the effects of factors that might influence resistance, such as ambient temperature. Figure 1 illustrates a typical Wheatstone bridge. In this bridge, the input voltage remains constant, while the output voltage varies according to the resistance values; additionally, the products of the opposing resistors are equal. The resistance R_x changes in response to the force applied to the strain gauges. The output voltage (V_G) is transmitted to the computer via a data acquisition card, and the signals are converted into force values using computer software.

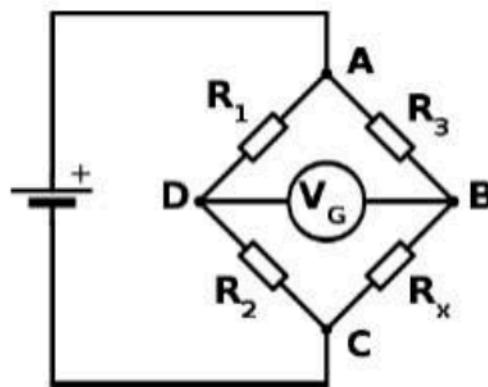


Figure 1. Wheatstone bridge.

Lift Force Coefficient

Lift: This is the component of the resultant aerodynamic force acting on the aircraft that is directed upwards, perpendicular to the free-stream flow. Here, "upwards" refers to the direction towards the pilot's head. For objects such as rockets where terms like "up" or "down" cannot be precisely defined, the direction of lift must be clearly specified accordingly. However, the fundamental point to note is that lift acts perpendicular to the direction of the free-stream flow. The formula for the lift coefficient is given in the equation below.

$$C_L = \frac{F_L}{\frac{1}{2}\rho v_\infty^2 S} \quad (1)$$

F_L = Lift force

ρ = Fluid density

V = Free-stream velocity

S = Airfoil surface area

Drag Force Coefficient

Drag: The component of force acting in the direction opposite to the aircraft's motion. It is the resistance force exerted by the air against the aircraft's movement.

$$C_D = \frac{F_D}{\frac{1}{2}\rho v_\infty^2 S} \quad (2)$$

F_D = Drag force

ρ = Fluid density

V = Free-stream velocity

S = Airfoil surface area

3.EXPERIMENTAL SETUP

The MSM-brand force measurement system used in this experimental study features a sensor capable of independently measuring lift and drag forces. The maximum measurable values are 110 N for lift force and 50 N for drag force. The force system is calibrated prior to the experiments; this process is carried out by suspending weights from a pulley system. The system acquires data at a rate of 1000 samples per second. Subsequently, the aerodynamic forces and coefficients are determined by averaging this data.

The magnitude of the forces acting on an airfoil varies depending on parameters such as fluid density, viscosity, airfoil surface area, and chord length. Therefore, it is necessary to render these values more practical for use by making them dimensionless.

4.RESULTS AND EVALUATION

Lift and drag coefficients will be calculated under the specified operating conditions, and a graph showing the variation of aerodynamic coefficients with the angle of attack will be plotted.

Angle of attack	F_L
1	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	

Angle of attack	F_D
1	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	