Lecture 7.5

Exp. Aero Lab 2: Aerodynamics of a Cambered Airfoil

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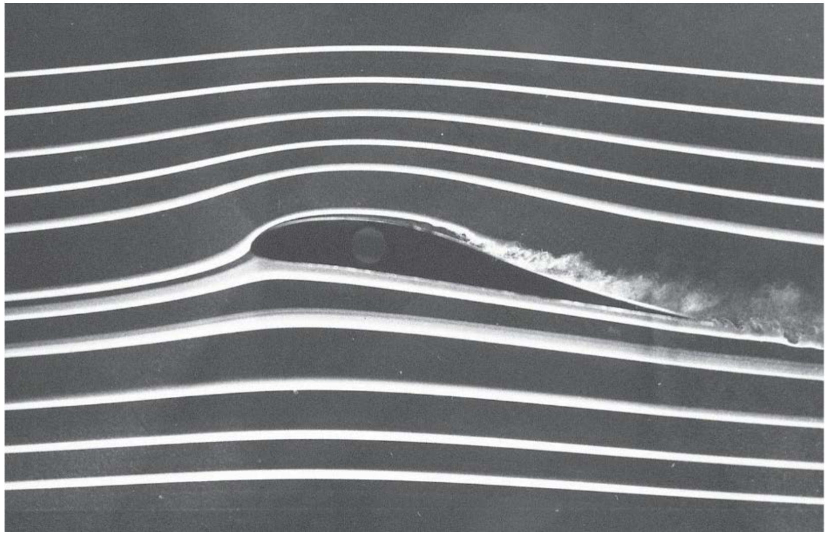
ITLL Aerolab Educational Wind Tunnel

<u>Goal:</u>

Asses the *aerodynamic performance* of a *simple cambered airfoil* through experimentally measuring its *two-dimensional pressure distribution* in the ITLL Wind Tunnel.

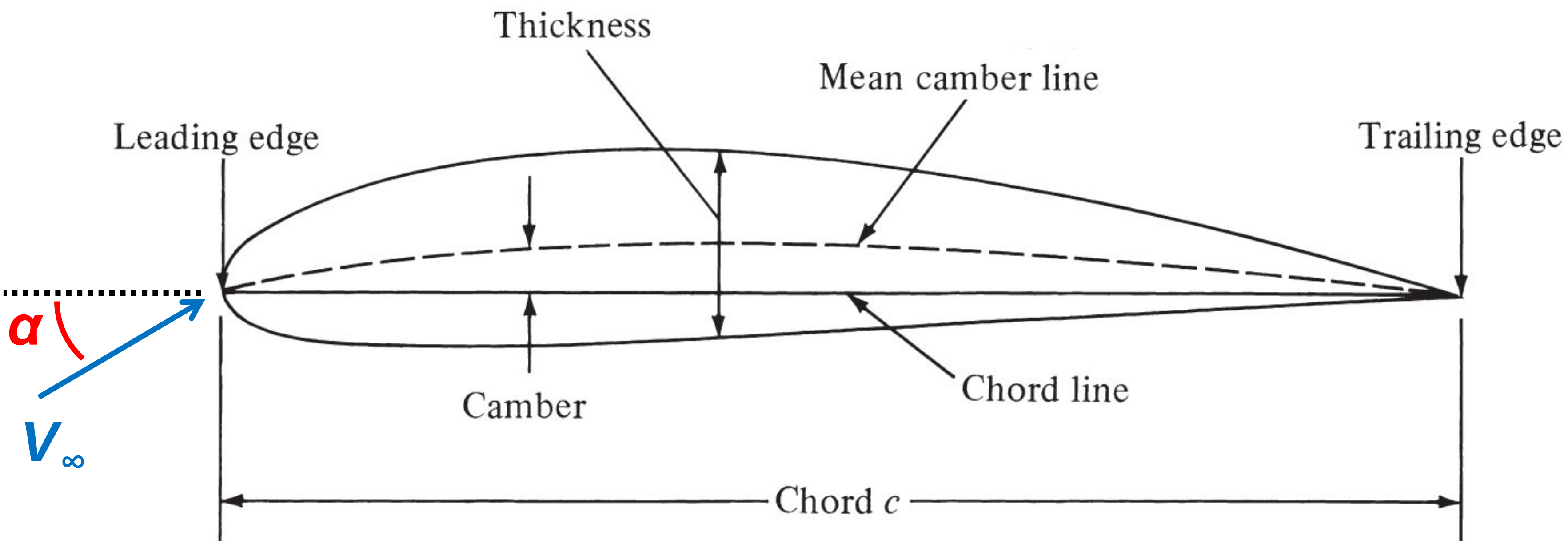


Exp. Aero Lab 2: Aerodynamics of a Cambered Airfoil

Learning Objectives:

1. *Learn basic concepts and definitions associated with two-dimensional flow around airfoils.*
2. *Gain an understanding of the origins of Lift and Drag through measuring and integrating the surface pressure distribution on a cambered airfoil.*
3. *Observe how changes in the Lift and Drag force coefficients are related to the angle of attack (flow incidence angle) and the free-stream velocity.*
4. *Develop an awareness of sources of error and error analysis.*

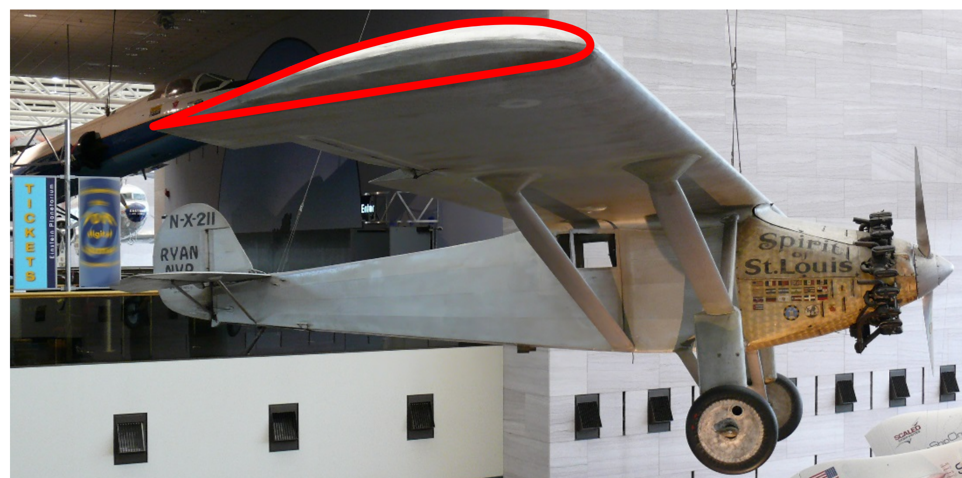
Anatomy of a Wing Section *(Airfoil)*



Simple Cambered Airfoil: Clark Y Airfoil

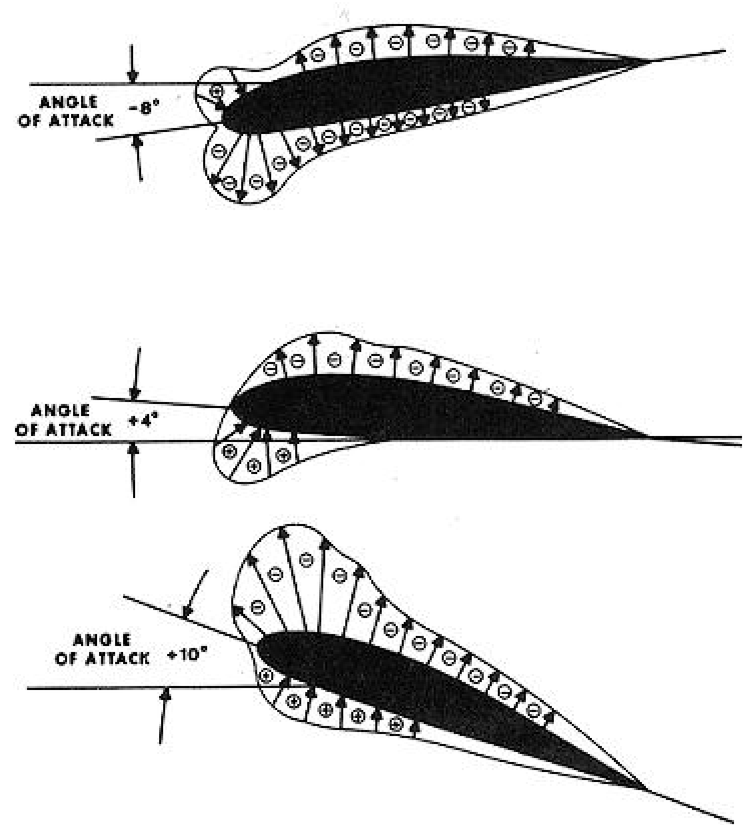
- There are many different shapes and configurations and families of airfoils:
  - **e.g.** NACA 4 digit (i.e. NACA 0012, NACA 2412)

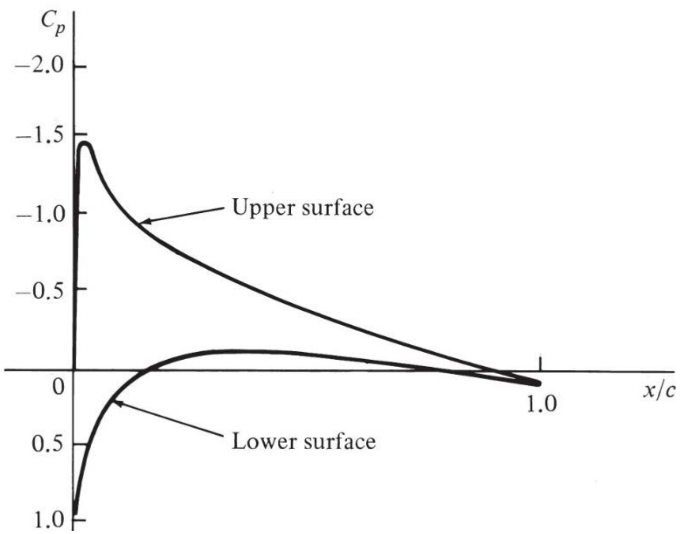
- A **Clark Y airfoil** is a classical configuration designed in 1922 by Virginius Clark.
  - Simple construction: Flat bottom Airfoil
  - 11.7% Thick Airfoil (Clark Y-14 is 14% Thick)
  - Commonly used in general aviation and RC Aircraft



Pressure Distribution: Theory

- *By now* we should all understand the concepts of **static** and **total (Stagnation) pressure**!
- The curvature of an airfoil surface causes the **static pressure** to locally vary ***<u>along</u>* the surface**.
- The **pressure distribution** can be **<u>altered by</u>** changing the **angle of attack (incidence)** between the airfoil and the oncoming flow.

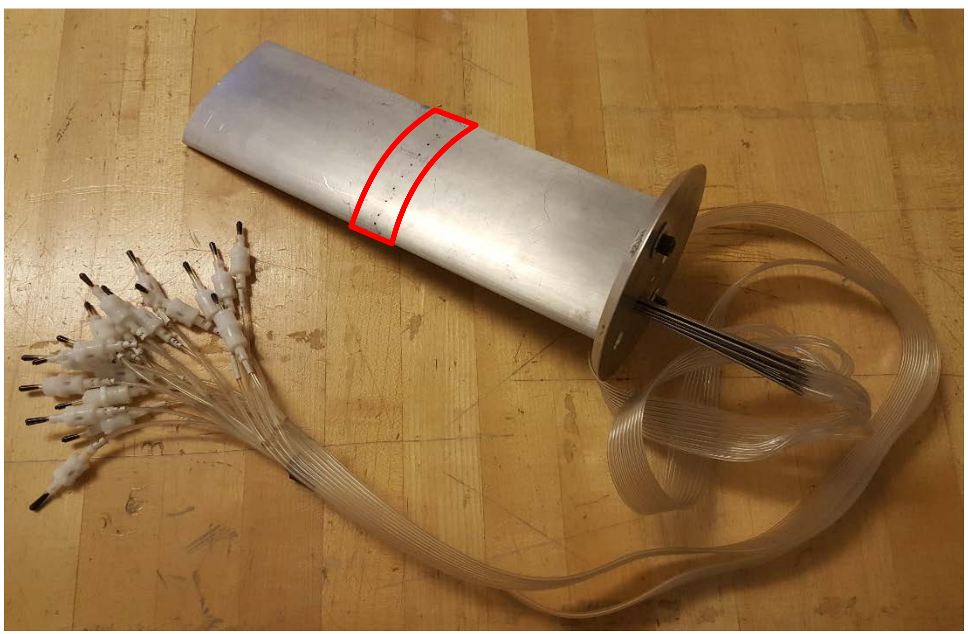




Pressure Distribution: Measurement

- We will map the pressure distribution around an airfoil by measuring the static pressure at 16 locations!
- Each pressure port will be measured as a differential pressure between the local surface location and the free-stream static pressure: $\Delta p = p_{n=1\ldots16} - p_{\infty}$

Clark Y-14 Wing Section with 20 static pressure ports



Scanivalve DSA3217 Pressure Scanner

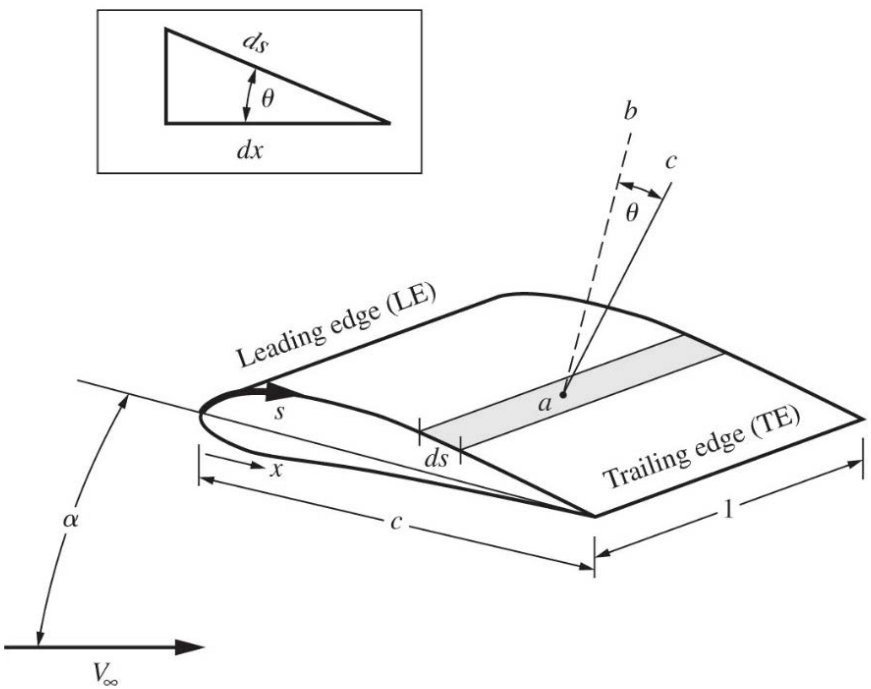
- 16 Differential Pressure Channels
- ±10 inH20

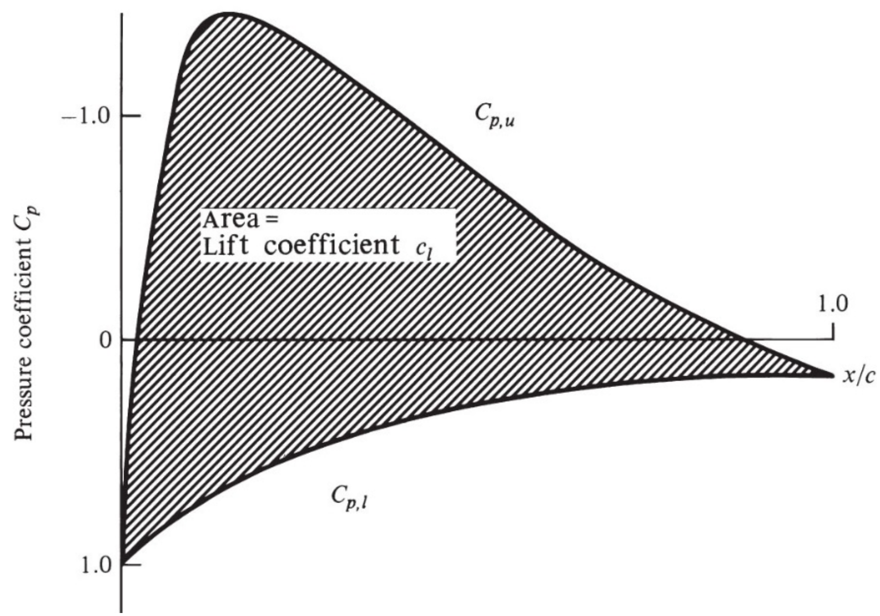
Pressure Distribution: Integration

- To compute the resultant forces on the airfoil section we will then need to integrate the pressure distribution along the surface:

$$F = \iint p_s dA = (span) \times \int p_s ds$$

  - Assume two-dimensional (i.e. we can multiple by a span-wise length)





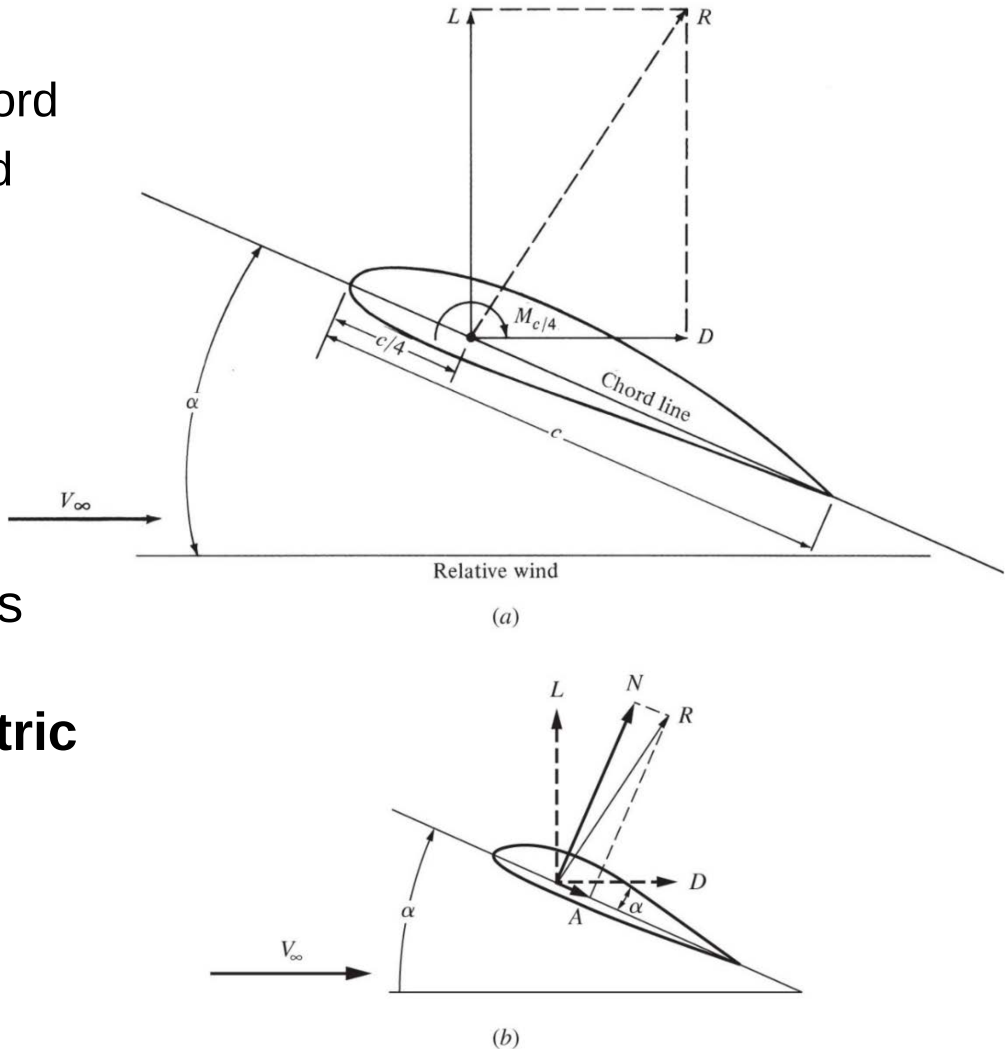
Aerodynamic Force Components

- **Computed Forces:**
  - **Normal (N)** – Normal to Chord
  - **Axial (A)** – Parallel to Chord

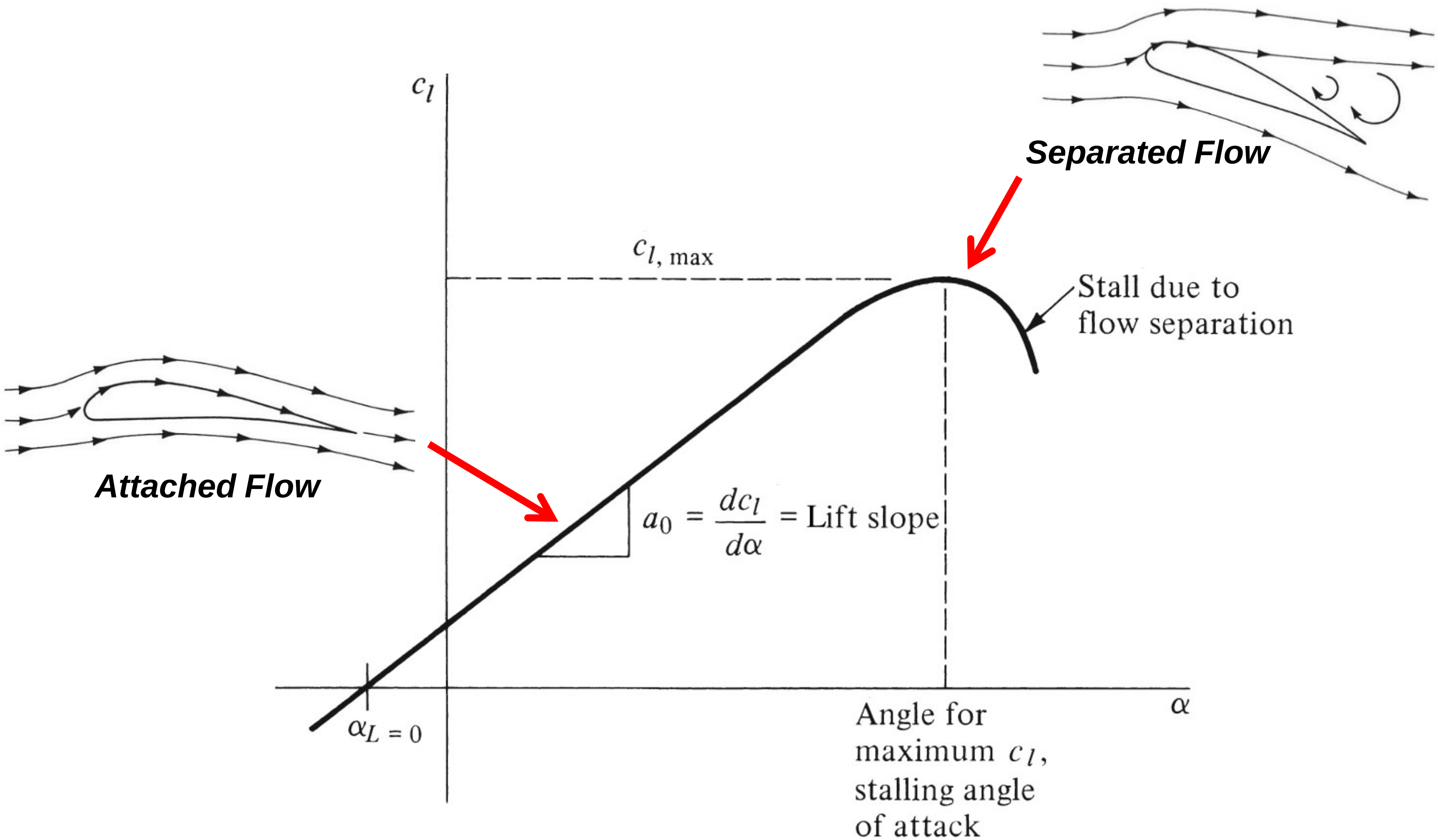
- **Desired Forces:**
  - **Lift (L)** – Normal to V_∞
  - **Drag (D)** – Parallel to V_∞

- Need to **transform** the forces into the desired components **based upon the trigonometric relationship** with $\boldsymbol{\alpha}$:

$$L = N \cdot cos(\alpha) - A \cdot sin(\alpha)$$
$$D = N \cdot sin(\alpha) + A \cdot cos(\alpha)$$



Typical Aerodynamic Performance of an Airfoil



Group Data Collection

Testing Date	Testing Time	Group Number	Team Members	Angles of Attack [deg.]	Velocities [m/s]	Filename
Wednesday November 11, 2015	9:15pm	**1**		-5, 5, 15	10, 20, 30	AirfoilPressure_S011_G01.csv
	9:43pm	**2**		-6, 4, 14	10, 20, 30	AirfoilPressure_S011_G02.csv
	10:11pm	**3**		-7, 3, 13	10, 20, 30	AirfoilPressure_S011_G03.csv

- All groups collect data at the same velocities but three different angles of attack!

$$\alpha = -15^o \ldots 15^o @ \Delta\alpha = 1^o$$