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VERSION	EFFECTIVE DATE	DESCRIPTION OF REVISION(S)
001	2015.01	Module creation and release.
002	2016.07	Format update and minor content revisions.
003	2018.07	Refined content sequencing to Appendix 1.
003.1	2023.04	Inclusion of Measurement Standards for clarification, page iv. Minor appearance and format updates.
004	2024.01	Regulatory update for EASA 2023-989 Compliance.

Module was reorganized based upon the EASA 2023-989 subject criteria. Enhancements included in this version 004 are:

8.1 *Atmospheric Density* - added content.
8.1 *Water Content* - added content.
8.2 *Free Stream Flow* - rewrite.
8.2 *Aerodynamic Contamination* - added content.
8.3 *Aircraft Performance* - rewrite.
8.4 *Shock Waves* - added new figure.

MEASUREMENT STANDARDS

SI Units
The measurements used in this book are presented with the International System of Units (SI) standards in all cases except when otherwise specified by ICAO (for example, altitude expressed in feet or performance numbers as specified by a manufacturer). The chart below can be used should your studies call for conversions into imperial numbers.

Number Groups
This book uses the International Civil Aviation Organization (ICAO) standard of writing numbers. This method separates groups of 3 digits with a space, versus the European method by periods and the American method by commas.

For example, the number one million is expressed as:

ICAO Standard	1 000 000
European Standard	1.000.000
American Standard	1,000,000

Prefixes
The prefixes used in the table below form names of the decimal equivalents in SI units.

PREFIX AND SYMBOLS CHART

MULTIPLICATION FACTORS	PREFIX	SYMBOL
1 000 000 000 000 000 000 = 10^{18}	exa	E
1 000 000 000 000 000 = 10^{15}	peta	P
1 000 000 000 000 = 10^{12}	tera	T
1 000 000 000 = 10^{9}	giga	G
1 000 000 = 10^{6}	mega	M
1 000 = 10^{3}	kilo	k
100 = 10^{2}	hecto	h
10 = 10^{1}	deca	da
0.1 = 10^{-1}	deci	d
0.01 = 10^{-2}	centi	c
0.001 = 10^{-3}	milli	m
0.000 001 = 10^{-6}	micro	µ
0.000 000 001 = 10^{-9}	nano	n
0.000 000 000 001 = 10^{-12}	pico	p
0.000 000 000 000 001 = 10^{-15}	femto	f
0.000 000 000 000 000 001 = 10^{-18}	atto	a

COMMON CONVERSIONS CHART

IMPERIAL	TO	SI (METRIC)
Distance		
1 Inch	is equal to	2.54 Centimeters
1 Foot	is equal to	0.304 Meters
1 (Statute) Mile	is equal to	1.609 Kilometers
Weight		
1 Pound	is equal to	0.454 Kilograms
Volume		
1 Quart	is equal to	0.946 Liters
1 Gallon	is equal to	3.785 Liters
Temperature		
˚0 Fahrenheit	is equal to	(-)17.778 Celsius (˚C)
˚0 Fahrenheit	is equal to	255.37 Kelvin (K)
Area		
1 Square Inch	is equal to	6.451 Square Centimeters
1 Square Foot	is equal to	0.093 Square Meters
1 Square Mile	is equal to	2.59 Square Kilometers
Velocity		
1 Foot Per Second	is equal to	0.304 Meters Per Second
1 Mile Per Hour	is equal to	1.609 Kilometers Per Hour
1 Knot	is equal to	1.852 Kilometers Per Hour

SI (METRIC)	TO	IMPERIAL
Distance		
1 Centimeter	is equal to	0.394 Inches
1 Meter	is equal to	3.28 Feet
1 Kilometer	is equal to	0.621 Miles
Weight		
1 Kilogram	is equal to	2.204 Pounds
Volume		
1 Liter	is equal to	1.057 Quarts
1 Liter	is equal to	0.264 Gallons
Temperature		
˚0 Celsius (˚C)	is equal to	33.8˚ Fahrenheit
˚0 Kelvin (K)	is equal to	(-)437.87 Fahrenheit
Area		
1 Square Centimeter	is equal to	0.155 Square Inches
1 Square Meter	is equal to	10.764 Square Feet
1 Square Kilometer	is equal to	0.386 Square Miles
Velocity		
1 Meter Per Second	is equal to	3.281 Feet Per Second
1 Kilometer Per Hour	is equal to	0.621 Miles Per Hour
1 Kilometer Per Hour	is equal to	0.540 Knots

Pressure

pounds per square inch (psi)	kiloPascals (kPa)	6.897
pounds per square inch (psi)	Pascals (Pa)	6.894

Qualification on basic subjects for each aircraft maintenance license category or subcategory is accomplished in accordance with the following matrix. Where applicable, subjects are indicated by an "X" in the column below the license heading.

EASA LICENSE CATEGORY CHART MODULE NUMBER AND TITLE		A1 Airplane Turbine	B1.1 Airplane Turbine	B1.2 Airplane Piston	B1.3 Helicopter Turbine	B1.4 Helicopter Piston	B2 Avionics
1	Mathematics	X	X	X	X	X	X
2	Physics	X	X	X	X	X	X
3	Electrical Fundamentals	X	X	X	X	X	X
4	Electronic Fundamentals		X	X	X	X	X
5	Digital Techniques, Electronic Instrument Systems	X	X	X	X	X	X
6	Materials and Hardware	X	X	X	X	X	X
7	Maintenance Practices	X	X	X	X	X	X
8	Basic Aerodynamics	X	X	X	X	X	X
9	Human Factors	X	X	X	X	X	X
10	Aviation Legislation	X	X	X	X	X	X
11	Aeroplane Aerodynamics, Structures and Systems	X	X				
12	Rotorcraft Aerodynamics, Structures and Systems				X	X	
13	Aircraft Aerodynamics, Structures and Systems						X
14	Propulsion						X
15	Gas Turbine Engine	X	X		X		
16	Piston Engine			X		X	
17	Propeller	X	X	X			

Basic knowledge requirments as outlined in Part-66, Appendix I

The knowledge level indicators are defined on 3 levels as follows:

Level 1
A familiarization with the principal elements of the subject.
Objectives:
a. The applicant should be familiar with the basic elements of the subject.
b. The applicant should be able to give a simple description of the whole subject, using common words and examples.
c. The applicant should be able to use typical terms.

Level 2
A general knowledge of the theoretical and practical aspects of the subject and an ability to apply that knowledge.
Objectives:
a. The applicant should be able to understand the theoretical fundamentals of the subject.
b. The applicant should be able to give a general description of the subject using, as appropriate, typical examples.
c. The applicant should be able to use mathematical formula in conjunction with physical laws describing the subject.
d. The applicant should be able to read and understand sketches, drawings and schematics describing the subject.
e. The applicant should be able to apply his knowledge in a practical manner using detailed procedures.

Level 3
A detailed knowledge of the theoretical and practical aspects of the subject and a capacity to combine and apply the separate elements of knowledge in a logical and comprehensive manner.
Objectives:
a. The applicant should know the theory of the subject and interrelationships with other subjects.
b. The applicant should be able to give a detailed description of the subject using theoretical fundamentals and specific examples.
c. The applicant should understand and be able to use mathematical formula related to the subject.
d. The applicant should be able to read, understand and prepare sketches, simple drawings and schematics describing the subject.
e. The applicant should be able to apply his knowledge in a practical manner using manufacturer's instructions.
f. The applicant should be able to interpret results from various sources and measurements and apply corrective action where appropriate.

PART 66 BASIC KNOWLEDGE REQUIREMENTS

Competency consists of knowledge, skills and attitude. The applicant for an aircraft maintenance licence, or for the addition of an aircraft category or subcategory in the aircraft maintenance licence, shall demonstrate by examination and practical assessment that they meet the competency requirements.

SUBMODULE KNOWLEDGE DESCRIPTIONS		LEVEL
		B1
8.1	**Physics of the Atmosphere** International Standard Atmosphere (ISA), and its application to aerodynamics.	2
8.2	**Aerodynamics** Airflow around a body; Boundary layer, laminar and turbulent flow, free stream flow, relative airflow, upwash and downwash, vortices, stagnation; The terms: camber, chord, mean aerodynamic chord, profile (parasite) drag, induced drag, centre of pressure, angle of attack, wash-in and wash-out, fineness ratio, wing shape and aspect ratio; Thrust, weight, aerodynamic resultant; Generation of lift and drag angle of attack, lift coefficient, drag coefficient, polar curve, stall; Aerofoil contamination including ice, snow, and frost.	2
8.3	**Theory of Flight** Relationship between lift, weight, thrust and drag; Glide ratio; Steady-state flights, performance; Theory of the turn; Influence of load factor: stall, flight envelope, and structural limitations; Lift augmentation.	2
8.4	**High-Speed Airflow** Speed of sound, subsonic flight, transonic flight, supersonic flight, Mach number, critical Mach number, compressibility buffet, shock wave, aerodynamic heating, area rule; Factors that affect airflow in engine intakes of high-speed aircraft; Effects of sweepback on critical Mach number.	2
8.5	**Flight Stability and Dynamics** Longitudinal, lateral, and directional stability (active and passive).	2

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BASIC AERODYNAMICS

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a low "hiss" will be heard. When the probe is in the turbulent area, a sharp "crackling" will be audible. In order to compare the characteristics of the laminar and turbulent boundary layers, the velocity profiles (the variation of boundary layer velocity with height above the surface) should be compared under conditions which could produce either laminar or turbulent flow.

The typical laminar and turbulent profiles are shown in **Figure 2-4**. The velocity profile of the turbulent boundary layer shows a much sharper initial change of velocity but a greater height (or boundary layer thickness) required to reach the free stream velocity. As a result of these differences, a comparison shows:

1. The turbulent boundary layer has a fuller velocity profile and has higher local velocities immediately adjacent to the surface. The turbulent boundary layer has higher kinetic energy in the airflow next to the surface.
2. At the surface, the laminar boundary layer has the less rapid change of velocity with distance above the surface. Since the shearing stress is proportional to the velocity gradient, the lower velocity gradient of the laminar boundary layer is evidence of a lower friction drag on the surface. In conditions of flow where a turbulent and a laminar boundary layer can exist, the laminar skin friction is about one-third that for turbulent flow. And while the low friction drag of the laminar boundary layer is desirable, the transition to turbulent boundary layer flow is natural and largely inevitable.

RELATIVE WIND / FREE STREAM FLOW

The relative wind is a relationship between the direction of the airflow and the aircraft wing. In normal circumstances, the relative wind is the opposite direction of the aircraft flight path.

- If the flight path is forward, then the relative wind is backwards.
- If the flight path is forward and upward, then the relative wind is backwards and downwards.
- If the flight path is forward and downward, the relative wind is backwards and upwards.

Therefore, the relative wind is parallel to the flight path and travels in the opposite direction.

Free Stream Flow, also known as relative airflow, is the air which is far enough upstream or away from the oncoming aircraft that its pressure, temperature, or relative velocity has not yet been or will not be affected by the aircraft's passage through it.

UPWASH AND DOWNWASH

Because the object in **Figure 2-1** is a symmetrical airfoil, the relative airflow striking it flows above and below the airfoil in the same manner. The pressures are the same and no lift is produced. By reshaping the airfoil or by tilting it in relation to the relative airflow, uneven flow over the upper and lower surfaces occurs. This causes uneven pressure above and below the airfoil which results in the creation of lift. Simply by tilting the same symmetrical airfoil, an increase in upper surface suction occurs and the decreased in velocity on the lower surface causes a decrease in lower surface suction. Also, upwash is generated ahead of the airfoil, the forward stagnation point moves under the leading edge, and a downwash is evident aft of the airfoil. (Upwash and downwash are the deflection directions of the air as it negotiates its path around the airfoil.) The pressure distribution on the airfoil now provides a net force perpendicular to the airstream in the upward direct. This is lift. [**Figure 2-5**] The creation of lift is discussed in greater detail below.

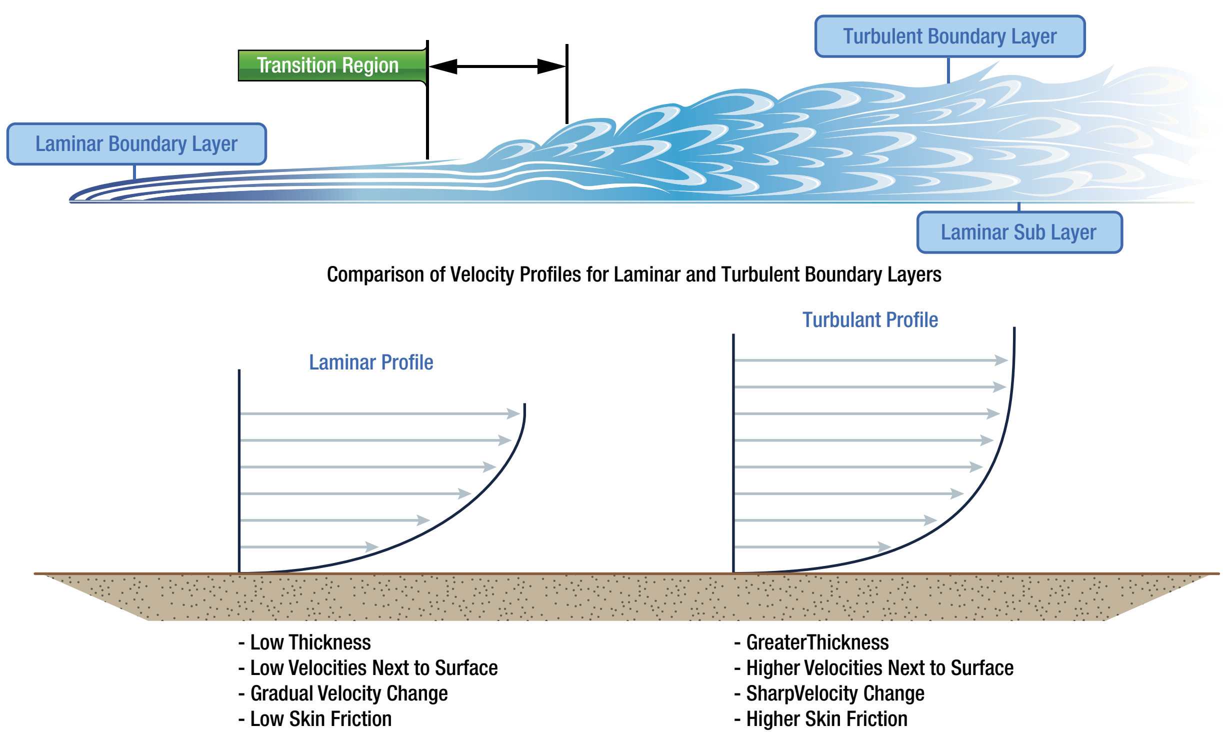

Figure 2-4. Boundary Layer Characteristics.

PLANFORM AND VORTICES

The previous discussion of aerodynamic forces concerned the properties of airfoil sections in two-dimensional flow with no consideration given to the influence of the *planform*. The planform is the shape or outline of an aircraft wing as projected onto a horizontal plane. [**Figure 2-6**] When the effects of wing planform are introduced, attention must be directed to the existence of flow components in the span-wise direction. In other words, the airfoil section properties considered thus far deal with flow in two dimensions. Planform properties consider flow in three dimensions.

The pressure above the wing is less than atmospheric pressure, and the pressure below the wing is equal to or greater than atmospheric pressure. Since fluids always move from high pressure toward low pressure, in addition to the movement of air over the wing from front to rear, there is also a spanwise movement of air from the bottom of the wing outward from the fuselage and upward around the wing tip. This flow of air results in spillage over the wing tip, thereby setting up a whirlpool of air called a "*vortex*." [**Figure 2-7**] The plural of vortex is vortices.

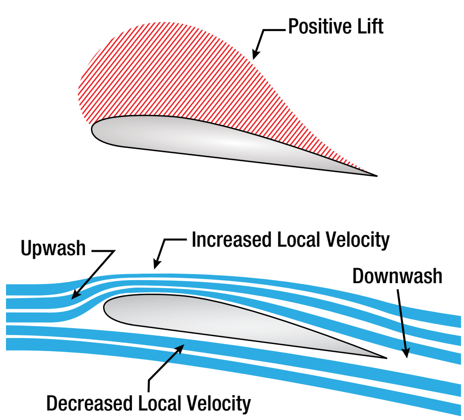

Figure 2-5. Uneven airflow, uneven pressure, upwash and downwash are all caused by tilting the airfoil in relation to the free stream airflow.

As the difference in the pressure between the air on the bottom and top of the wing increases, more lift is generated. This increased pressure differential also causes more violent vortices. Small aircraft pilots must be especially vigilant when flying behind large aircraft. The vortices coming off the wingtips of a transport category aircraft could cause loss of control if encountered before they have had time to dissipate into the atmosphere.

Note that the air on the upper surface of the wing planform has a tendency to move in toward the fuselage and off the trailing edge as shown by the blue arrows in **Figure 2-7**.

This air current forms a similar vortex to a wingtip vortex but at the inner portion of the trailing edge of the wing. All vortices increase drag because of the turbulence produced, and constitute induced drag. Vortices increase as lift (and drag) increase. Drag will be discussed in further detail later in this module.

Just as lift increases by increasing of the angle of the airfoil into the wind, drag also increases as the angle becomes greater. This occurs because, within limits, as the angle is increased, the pressure difference between the top and bottom of the wing becomes greater. This causes more violent vortices to be set up, resulting in more turbulence and more induced drag.

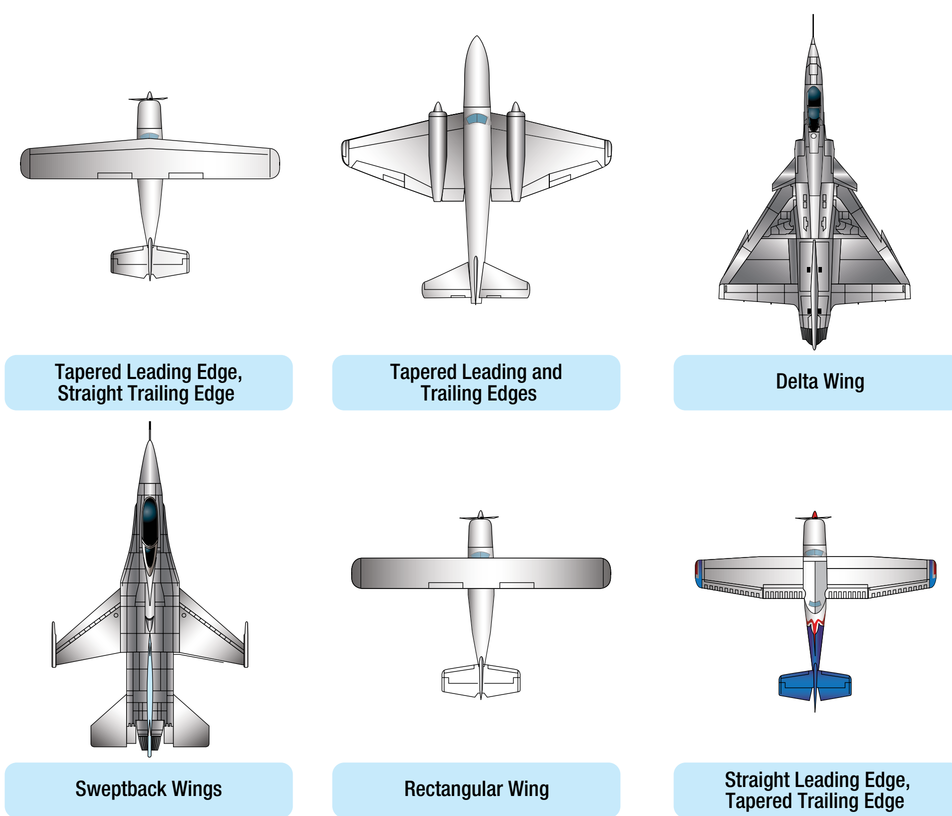

Figure 2-6. Various wing planforms.

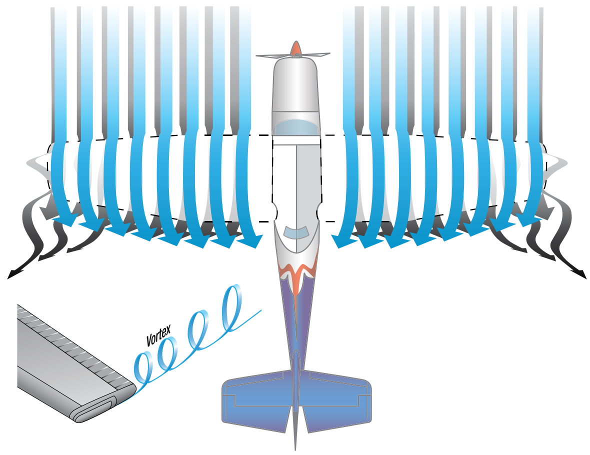

Figure 2-7. Wingtip vortices.

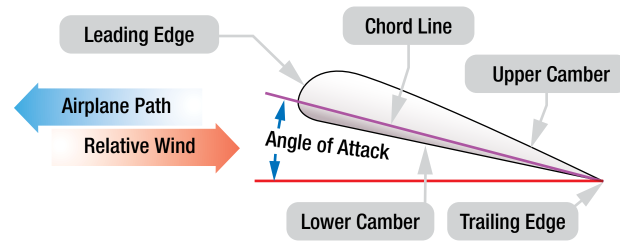

Figure 2-8. Wing terminology.

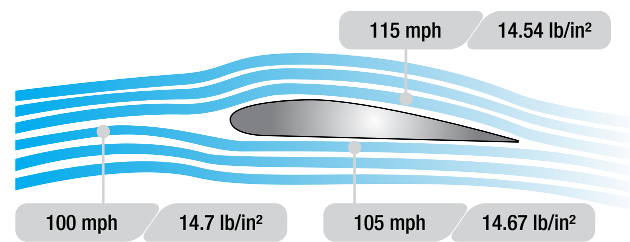

Figure 2-9. Airflow over a wing section.

AERODYNAMIC TERMS

AIRFOILS

An airfoil is any device that creates a force, based on Bernoulli's principles or Newton's laws, when air is caused to flow over the surface of the device. An airfoil can be the wing of an airplane, the blade of a propeller, the rotor blade of a helicopter, or the fan blade of a turbofan engine. The wing of an airplane moves through the air because the airplane is in motion, and generates lift by the process previously described. By comparison, a propeller blade, helicopter rotor blade, or turbofan engine fan blade rotates through the air. These rotating blades could be referred to as rotating wings, as is common with helicopters when they are called rotary wing aircraft. The rotating wing can be viewed as a device that creates lift, or just as correctly, it can be viewed as a device that creates thrust.

In **Figure 2-8** an airfoil, or wing, is shown, with some of the terminology that is used to describe a wing.

Since an airfoil is a surface designed to obtain lift from the air through which it moves, it can be stated that any part of the aircraft that converts air resistance into lift is an airfoil. The profile of a conventional wing is an excellent example of an airfoil. [**Figure 2-9**]

Notice that the top surface of the wing profile has greater curvature than the lower surface.

The difference in curvature of the upper and lower surfaces of the wing creates the lifting force. Air flowing over the top surface of the wing must reach the trailing edge of the wing in the same amount of time as the air flowing under the wing. To do this, the air passing over the top surface moves at a greater velocity than the air passing below the wing because of the greater distance it must travel along the top surface. This increased velocity, according to Bernoulli's Principle, means a corresponding decrease in pressure on the upper surface. Thus, a pressure differential is created between the upper and lower surfaces of the wing, forcing the wing upward in the direction of the lower pressure.

CHORD AND CHAMBER

Before continuing the discussion on aerodynamics, some terms are defined and illustrations considered. The *chord* of a wing is the width of the wing from the leading edge apex to the trailing edge. A *chord line* is a line depicting the chord which extends forward of the leading edge. It is used for angular reference to the chord. [**Figure 2-10**] The average chord is the area of the wing divided by the wing span. The *mean aerodynamic chord* is the average distance from the leading edge to the trailing edge of the wing. Due to the many wing planform designs, the mean aerodynamic chord is not necessarily half way from the fuselage to the wing tip as it is on a perfectly rectangular wing. However, the mean aerodynamic chord has half of the surface area of the

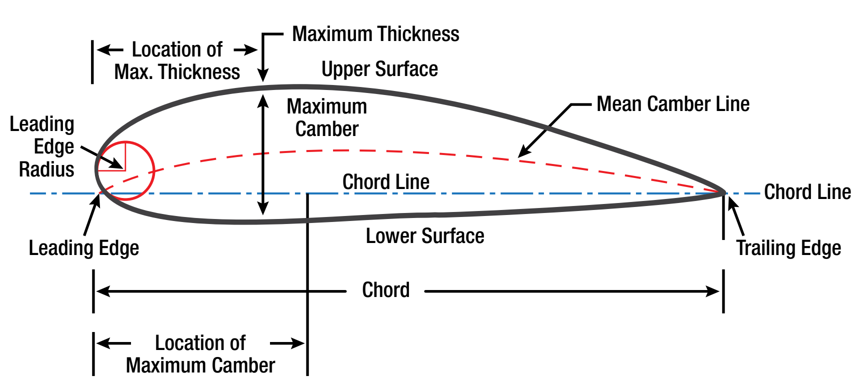

Figure 2-10. Chord and Chamber of a wing.