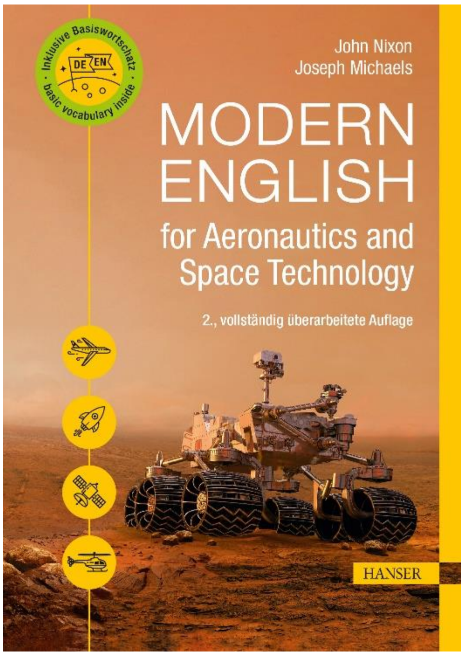
HANSER




# Leseprobe

zu

# Modern English for Aeronautics and Space Technology


von John D. Nixon und Joseph Michaels



Print-ISBN: 978-3-446-46863-4
E-Book-ISBN: 978-3-446-47011-8


Weitere Informationen und Bestellungen unter
https://www.hanser-kundencenter.de/fachbuch/artikel/9783446468634
sowie im Buchhandel

# Contents

# Preface

This book started as a collection of exercises and texts that were developed for English for Specific Purposes (ESP) courses in the English Department at the University of Stuttgart's Language Center – English for Aeronautics and English for Space Engineering. The texts that formed the foundation of the readers had been drawn from various sources, such as scientific magazines, academic journals, textbooks and the Internet, and served as authentic material through which the students could hone their English language skills. These materials were the genesis of the first edition of this textbook, which was published in 2011. For the second edition, John Nixon has been joined by his colleague Joseph Michaels to update the information and reflect current trends in aerospace engineering, which can be found in the second half of the book.

This book is intended as a textbook to accompany ESP courses at post-secondary institutions across the German-speaking world, but, if one disregards the translation exercises involving German, it could easily be used for English for aerospace classes anywhere. Additionally, this textbook can be used by engineers already working in the field of aerospace engineering as part of a structured course or a self-study module.

While there is no pre-requisite per se for the course in which this book is meant to be used, students are generally required to have a firm grasp of the English language. The level that has been aimed for is C1 (Common European Framework of Reference for Languages) or UNIcert Level III.

As the material has been taken from a number of sources in its original context, the variety of English might vary from text to text. Consequently, the British English "centre", for example, might figure next to its American equivalent "center". The differences between these types of English are covered in chapter 12.

This book is a combination of reader and workbook. Space has generally been provided for students to enter their answers into the book as they work through the exercises under the guidance of an instructor or on their own as part of a self-study module.

Although there is a large focus on reading comprehension, the expansion of specialized and academic vocabulary as well writing skills, there are exercises throughout the textbook that provide practice in listening comprehension and speaking. A few task-oriented exercises have also been provided to allow the students to employ all of their English-language resources in authentic, real-life situations.

We cannot vouch for the accuracy of the information provided in the material that we have gathered, but we have endeavoured to ensure that the material has been drawn from reputable sources.

Thanks goes to a number of individuals who provided help and advice along the way. In particular, we would like to thank Paula Cilinghir, who was of enormous assistance with the layout and graphics. We are also indebted to our aerospace students, without whose enthusiasm for English and for their field of study this book would never have come about.

Lastly, we would like to thank the Carl Hanser Verlag for their continued support with this manuscript as well as for their ideas regarding formatting, graphics and illustrations.

Stuttgart, May 2021

*John D. Nixon*

*Joseph Michaels*

# 1 Aerodynamic Forces

## 1.1 Introductory Discussion

*There are numerous forces acting on objects in everyday life.*

*For example, which forces are at play on a boat floating on water?*

*What about a rock on an incline that doesn't roll down the slope?*

*Which of these forces operate on an aircraft in flight? Are there any others?*

*Discuss the preceding introductory questions and then fill in the table below.*

| Object | Forces Acting on it |
|---|---|
| Boat | |
| Rock | |
| Airplane | |

# 1.2 Exercises

## 1.2.1 Exercise A

*Read the following text and fill in the blanks with the words presented here.*

| | | | |
|---|---|---|---|
| denotes | resists | magnitude | adjust |
| opposing | overcome (x2) | payload | generate |
| consumes | varied | | |

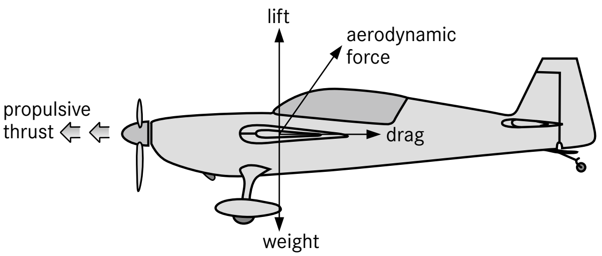



**Figure 1.1** Overview of the four aerodynamic forces acting on an airplane

**Weight**

Weight is a force that is always directed toward the center of the earth. The magnitude of the weight depends on the mass of all the airplane parts, plus the amount of fuel, plus any ____________________ (1) on board (people, baggage, freight, etc.). The weight is distributed throughout the airplane. But we can often think of it as collected and acting through a single point called the center of gravity. In flight, the airplane rotates about the center of gravity.

Flying encompasses two major problems: overcoming the weight of an object by some opposing force, and controlling the object in flight. Both of these problems are related to the object's weight and the location of the center of gravity. During a flight, an airplanes' weight constantly changes as the aircraft ____________________ (2) fuel. The distribution of the weight and the center of gravity also changes. So, the pilot must constantly ____________________ (3) the controls to keep the airplane balanced or trimmed.

### Lift

To ______________________ (4) the weight force, airplanes generate an ______________________ (5) force called lift. Lift is generated by the motion of the airplane through the air and is an aerodynamic force. “Aero” stands for air and “dynamic” ______________________ (6) motion. Lift is directed perpendicular to the flight direction. The magnitude of the lift depends on several factors including the shape, size and velocity of the aircraft. As with weight, each part of the aircraft contributes to the aircraft lift force. Most of the lift is generated by the wings. Aircraft lift acts through a single point called the center of pressure. The center of pressure is defined just like the center of gravity, but using the pressure distribution around the body instead of the weight distribution.

### Drag

As an airplane moves through the air, there is another aerodynamic force present. The air ______________________ (7) the motion of the aircraft and the resistance force is called drag. Drag is directed along and opposed to the direction of flight. Like lift, there are many factors that affect the ______________________ (8) of the drag force including the shape of the aircraft, the “stickiness” of the air, and the velocity of the aircraft. Like lift, we collect all of the individual components’ drags and combine them into a single aircraft drag magnitude. And like lift, drag acts through the aircraft center of pressure.

### Thrust

To ______________________ (9) drag, airplanes use a propulsion system to ______________________ (10) a force called thrust. The direction of the thrust force depends on how the engines are attached to the aircraft. On many planes, two turbine engines are located under the wings and parallel to the body, with thrust acting along the body centreline. On some aircraft, such as the Harrier, the thrust direction can be ______________________ (11) to help the airplane take off over a very short distance. The magnitude of the thrust depends on many factors associated with the propulsion system including the type of engine, the number of engines and the throttle setting.

(adapted from NASA Glenn Research Center, Aerodynamics Index)

### 1.2.2 Exercise B: Vocabulary

*Look at the previous text extracts and try to answer the questions below with a partner.*

1. What is the difference between weight and mass?

2. What is the difference between speed and velocity?

3. What is meant by perpendicular? (see text on **Lift** above)

### 1.2.3 Exercise C: Translation

*Translate the following text into English.*

Auf ein Flugzeug, das sich gerade im Flug befindet, wirken immer vier Kräfte ein: der Auftrieb, die Schwerkraft (also das Gewicht des Flugzeugs), der Schub (oder auch Vortrieb genannt) und der Widerstand. Wie man sich vorstellen kann, sind

Auftrieb und Schwerkraft gegeneinander gerichtet, und dasselbe gilt auch für den Vortrieb (Schub) und den Widerstand. Der Auftrieb ist das wesentlichste Element beim Fliegen. Während des Fluges wirken aber noch andere Kräfte auf das System ein und in deren Zusammenspiel ergibt sich das Flugverhalten des Geräts.

(adapted from Drachen- und Gleitschirmclub, *www.dgcb.de*)

## 1.3 Why an Aircraft Flies

The following text was considered for a long time the traditional explanation, but is now deemed incomplete. While you read this text, try to determine what piece of information has been proven incorrect through wind tunnel tests.

1. As an aircraft is “heavier than air”, it needs an upward force to keep it aloft. This force is provided by the “lift” developed by the supporting surfaces (wings) and is directed at right angles to the direction of movement. In addition, the air offers a certain frictional resistance, called “drag”. By suitable design of the cross-sectional shape of the wing, the drag can be kept small in relation to the lift. A shape of this kind is known as an airfoil section (Figure 1.2).

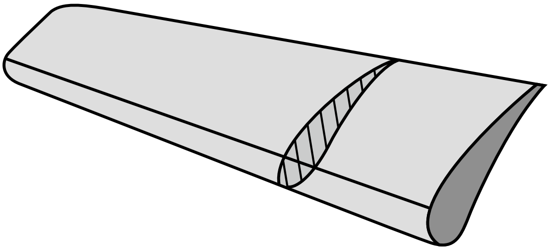


**Figure 1.2** Airfoil section

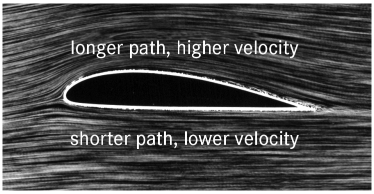



**Figure 1.3** Airflow around an airfoil

2. When the wing of an aircraft moves forward through the air, the flow of air along the lower surface arrives at the trailing edge before the flow along the upper surface. The lower surface flow attempts to expand around the trailing edge. As a result of this, a vortex is formed. The rotation of this vortex accelerates the upper surface flow, so that the length of time required for a particle of air to move from the leading edge to the trailing edge becomes the same for the upper and the lower surface flow. The increased velocity of the upper surface flow eliminates the formation of a vortex by the lower surface air at the trailing edge, and it produces a lower pressure at each point on the upper surface than exists at the corresponding points on the lower surface. It is this difference in pressure that produces the lift. The distribution of lift along the cross-section of a wing is illustrated by the pressure-distribution diagram (Figure 1.4). The magnitude of the forces changes with the angle of attack (or angle of incidence), i. e. the angle between the direction of the air flow and the chord line of the wing (Figure 1.5). The resultant aerodynamic force acts at the centre of pressure (Figure 1.4); its position varies with the angle of attack. The stability of an aircraft is significantly determined by the displacement of the centre of pressure. With an increasing angle of attack, this point moves forward. When the angle is increased beyond the value that produces maximum lift, “stall” occurs: this results in loss of flying speed and lift and finally loss of control; the air flow detaches itself from the upper surface (Figure 1.6).

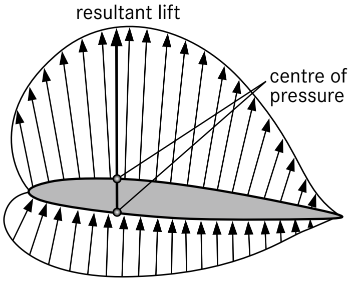



**Figure 1.4** Pressure distribution diagram

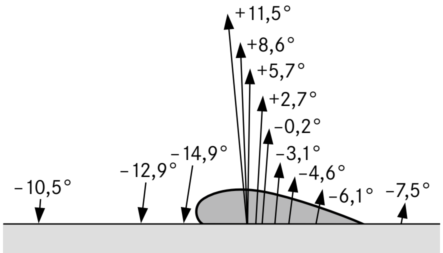



**Figure 1.5** Variation of forces and position of centre of pressure with angle of attack

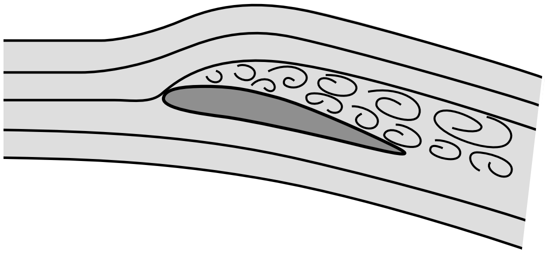


**Figure 1.6** Formation of Stall

3. The airfoil section is so shaped as to present minimum air resistance at the design speed of the aircraft and at the same time provide the necessary amount of lift. Figs. 1.7a and 1.7b represent the wing sections of a cargo-carrying aircraft and a faster aircraft respectively. The lift provided by the thick highly curved wing is about half as much again as that of the thinner and flatter wing, but its drag is about twice as high.

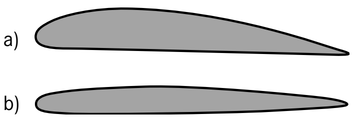



**Figure 1.7** Different airfoils

4. The principles of airfoil design are also applicable to propeller blades. The function of the propeller is to convert the torque developed by the engine into a propulsive thrust to drive the aircraft forward. This thrust is produced by acceleration of the air around the propeller. Since the velocity at each blade section is a function of radius, the blades are twisted to maintain a favourable angle of attack all along the blade. The principal forces and velocities associated with the action of the propeller are shown in Figure 1.8. The pitch angle of the propeller blade corresponds to the angle of attack of the wing: it is the angle between the blade chord line and the plane of rotation. A variable-pitch propeller is designed to maintain propeller efficiency as the forward velocity changes. The pitch setting can be changed while the propeller is rotating.

Source: How things work

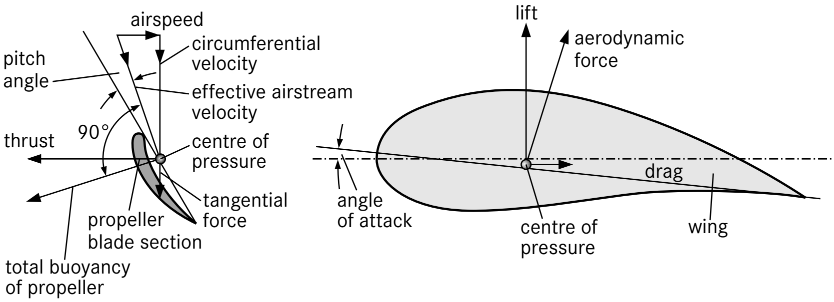



**Figure 1.8** Cross-section of an airfoil and the various forces at work

## 1.3.1 Exercise A: Comprehension

*Based on the text above, answer the following questions using full sentences.*

1. Define the concepts “lift” and “drag”.

___

___

___

___

___

___

___

2. How is lift produced?

3. What factor determines the stability of an aircraft?

4. How does the wing shape of a cargo plane differ from that of a faster aircraft?

5. What is the function of a propeller?

6. What is a variable-pitch propeller?

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

## 1.3.2 Exercise B: Vocabulary

**Paragraph One**

a) What does ‘aloft’ mean?

b) What German word is ‘loft’ related to?

c) Can you think of other words with the same type of structure ‘a’ + ‘noun’/‘adj’ = ‘adj’ or ‘adverb’

**Paragraph Two**

d) What is the opposite of ‘accelerate’?

e) What is the plural of ‘aircraft’?

**Paragraph Three**

f) What is the purpose of the word ‘respectively’ in the second sentence?

g) Create a sentence using the structure ‘so + adj. + as to’ found in this paragraph.

**Paragraph Four**

h) What does the word ‘maintain’ mean in the text here? What is another meaning, which is not found in the text?

i) Define ‘torque’.

j) Word formation: propeller

→______________________ (verb)

→______________________ (adj.)

### 1.3.3 Exercise B: Part Two

*Read this aerodynamics course description from the University of Michigan. Fill in the missing words with the words below. Note that there are not enough words and that you will have to come up with a few on your own. Refer back to the text you just read to find the answers.*

**aerodynamics** **separation** **calculated** **concepts**

This course deals with the fundamental ______________________ in aerodynamics. Students learn how ______________________ produce lift, and how the pressure ______________________ about an airfoil can be ______________________. The course also introduces the boundary-layer concept, how boundary ______________________ lead ______________________ drag, and what makes them prone to instability or ______________________. It covers the effects of the wing planform shape on lift and drag and includes an introduction to airfoil design and high-speed ______________________.

### 1.3.4 Exercise C: Writing

*In your own words and using complete sentences, try to explain the function of wings and engines on an airplane. Focus on the role of these airplane parts as they relate to aerodynamic forces.*


**Figure 1.9** GP 7000

## ■ 1.4 How Does an Aircraft Really Fly?

In this text a fuller picture is presented of how lift is generated.

1. Lift is the force that holds an aircraft in the air. How is lift generated? There are many explanations for the generation of lift found in encyclopedias, in basic physics textbooks, and on Web sites. The proponents of the arguments usually fall into two camps: (1) those who support the Bernoulli position that lift is generated by a pressure difference across the wing, and (2) those who support the Newton position that lift is the reaction force on a body caused by deflecting a flow of gas.

2. When a gas flows over an object, or when an object moves through a gas, the molecules of the gas are free to move about the object; they are not closely bound to one another as in a solid. Because the molecules move, there is a velocity associated with the gas. Within the gas, the velocity can have very different values at different places near the object. Bernoulli's equation relates the pressure in a gas to the local velocity; so as the velocity changes around the object, the pressure changes as well. Adding up (integrating) the pressure variation times the area around the entire body determines the aerodynamic force on the body. The lift is the component of the aerodynamic force which is perpendicular to the original flow direction of the gas. The drag is the component of the aerodynamic force which is parallel to the original flow direction of the gas.

**Figure 1.10** Airbus A350

Adding up the velocity variation around the object instead of the pressure variation also determines the aerodynamic force. The integrated velocity variation around the object produces a net turning of the gas flow. From Newton's Third Law of Motion, a turning action of the flow will result in a re-action (aerodynamic force) on the object.

So both Bernoulli and Newton are correct. Integrating the effects of either the pressure or the velocity determines the aerodynamic force on an object. We can use equations developed by each of them to determine the magnitude and direction of the aerodynamic force.

(adapted from *www.grc.nasa.gov*)

## 1.4.1 Exercise A: Diagram

*Draw and label a diagram illustrating how lift is generated on an airfoil using the Newtonian explanation.*

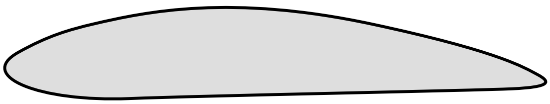


**Figure 1.11**

### 1.4.2 Exercise B: Discussion Questions

*With a partner discuss the following questions:*

Is this the complete explanation of how airplanes fly?

What are the Navier-Stokes equations?

If scientists and engineers have a hard time predicting how objects will behave in a moving liquid such as air, what consequences does that have for airplane manufacturers?

### 1.4.3 Exercise C: Language Corrections

*Look at the sentences below and make all the necessary corrections. The mistakes can be related to either grammar, vocabulary or spelling.*

1. The wings produce lift if the aircraft moves thru the air.

2. Engines are most often directed so that thrust works in opposite direction than the velocity of flight.

3. The air on the upper side moves faster. By this the pressure becomes smaller.

4. The movement of the wing, and so the plane, has to be fast enough to produce a difference in pressure.

5. This airfoil should produce a small as possible amount of drag.

6. Lift is an upward force that overcomes the gravity.

7. Drag and thrust are opposing each other.

8. The difference in pressure generates the force mentioned on the beginning.

9. But this principal is only possible when the aircraft is moving forward.

10. On conventional aircraft designs, the ailerons and flaps are also attached to the wings.

11. The wings of an airplane produce the mean part of the lift.

12. Engines on an airplane produces the necessary thrust to overcome drag.

13. Wings accelerate the air flow by the upper part of the airfoil.

14. Drag must be opposed by propulsive thrust, as the plane otherwise would decelerate and loose height.

15. On the upper side of the wing, the air has to go a larger distance.

16. The air moves faster and this results an area of low pressure.

17. Lift results of the difference between the pressure at the upper and lower surface of an airfoil.

18. Because of the higher velocity on the upper surface you receive a lower pressure.

19. You must reach a velocity which gives the possibility to lift and to keep the aircraft aloft.

________________________________________

________________________________________

20. Engines have the function of making the plane move forward.

________________________________________

________________________________________


**Figure 1.12** Airbus A320neo

# 1.5 James Bond 007—Reading Numbers Aloud in English

## 1.5.1 Multiple Digits

1. In English, digits of phone numbers, credit cards, bank accounts, etc. are usually read out one by one.
   Hence, the credit card number **4980 7065 3245 9128** is read as
   `four nine eight oh seven oh six five three two four five nine one two eight`
   It is not customary to group numbers together as in German, e.g.
   `forty-nine, eighty, seventy, sixty-five ...`
2. In British English, quite often identical digits side by side are read as double, triple (treble)
   *How would you say the following?*
   James Bond 007
   777-5672

## 1.5.2 Zero

There are many different ways of saying **zero** in English.

1. **zero** and **oh**
   These two forms are the most common.
   a) When numbers are said aloud one at a time, the British tend to say ‘oh’ for 0 and North Americans ‘zero’.
      e. g. “My account number is four one three oh six.” (in the UK)
      “My account number is four one three zero six.” (in North America).
   However, numbers may be ‘chunked’ together. That is, a North American may say ‘highway four oh one’ for ‘Hwy. 401’ or the telephone area code for Washington D. C. is ‘two oh two’. This occurs when the speaker considers the group of numbers as one unit or is very familiar with them.
      e. g. ‘Beverley Hills 90210’
   Because it has just one syllable as compared to the two-syllable ‘zero’, ‘oh’ is often used in the interest of speed and euphony. However, ‘zero’ is often clearer, especially on the phone, and leads to fewer misunderstandings.
   b) Age and Counting Items
   When referring to a person’s age or when counting items, one will neither say ‘oh’ nor ‘zero’.
      e. g. “My great-grandmother is one hundred and two.”
      “There are a hundred and five lines in this text.”
   however
      “Please refer to page one oh five.” (p. 105)
   Here the speaker is not counting, but simply referring to a single item.
2. **nought** sometimes before decimals 0.004
   This occurs only in British English. An American would not understand “nought”.
3. We say **nil/nothing** in sports
   five nil (UK)
   five nothing (US)
   In tennis, we say **love**, however, for zero. (‘Love’ supposedly originates from the French l’oeuf.)
   Nil can also refer to zero, as in
      “The chances of a first-year student getting into this class are nil.”

**N. B.**

Oh and zero are usually interchangeable.

Sometimes expressed as nought in the UK before the decimal point.

German *Null* translates as zero and not null, which is restricted to certain expressions like null and void *(nichtig)* or the null set *(Nullmenge).*

### 1.5.3 The Decimal Point

To separate thousands, millions and so on, we use a **comma** (,).

25,000 = twenty-five thousand

but a dot (.) is used and not a comma (,) for decimals in English.

25.000 = twenty-five point oh oh oh
0.005 = zero point oh oh five

### 1.5.4 Plural Forms and False Friends

1. plural forms, **no /s/**
   There is no /s/ on million, billion, etc.
   e. g. 82,000,000 = eighty-two million
   exception → for large, non-specific, uncertain quantities, e. g. many, countless, etc. in conjunction with of
   e. g. "Countless millions of euros are wasted in Brussels yearly."
   "The star is thousands of light years away."
   "Many hundreds of thousands of people died in the tsunami in Asia."
   **N. B.**
   This does not apply to a few and several. Here there is no /s/.
   e. g. "The US budget amounts to several trillion dollars."
2. False Friends (billion/Billion)
   *How would you translate ten billion into German?*
   *How would you translate zehn Billionen into English?*

### 1.5.5 Dates

1. In modern English, it is customary to express dates differently than in German.
   e. g. 1985 (year) nineteen eighty-five
   and not nineteen hundred and eighty-five
   (This is likely different from what you learned in school!)
2. With a 0 digit in the year, we say 'oh'.
   1402 (year) fourteen oh two
3. The new millennium
   Will we continue to use two thousand and... or revert to the original paradigm of twenty ...?

| | |
|---|---|
| 1999 (year) | nineteen ninety-nine |
| 2000 (year) | two thousand |
| 2009 (year) | two thousand and nine |
| 2020 (year) | two thousand and twenty |
| | OR twenty twenty |

### 1.5.6 Fractions

Ordinal numbers *(Ordinalzahlen)* are usually used, with the exception of half and quarter. How would you read the following?

1/2
2/3
3/4
4/5
7/9

When the denominator reaches a certain point, the fraction will be read differently.

1 = numerator
3 = denominator

e.g. $\frac{5}{212}$ five over two hundred and twelve

### 1.5.7 Percent

It can be written as one word **percent** or two **per cent.**

Make sure that the tonic accent falls on the second syllable, i.e. that the second syllable is stressed.

Otherwise, it sounds like person!

# 2 Wings and Airfoils

## ■ 2.1 Wing Geometry Definitions

### 2.1.1 Exercise A: Basic Vocabulary

a) *Match the letters in the following diagrams with the words provided.*

| | | | |
|---|---|---|---|
| camber | chord | chord line | mean camber line |
| leading edge | trailing edge | airfoil | dihedral angle |
| span | tip | aspect ratio | wing area |
| thickness | centreline | wing planform | wing root |

**Top View (or A)**

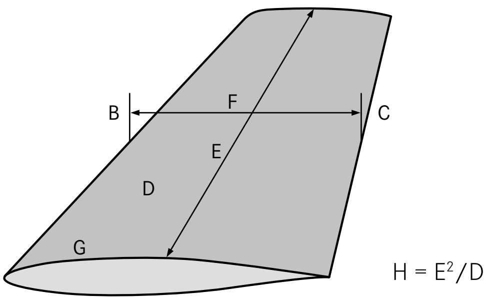



**Figure 2.1** An Airfoil Seen from Above

**Side View (or I)**

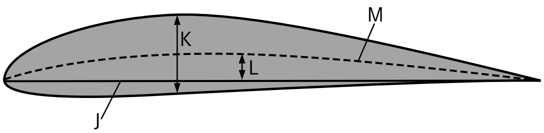



**Figure 2.2** Cross-sectional View of an Airfoil

**Front View**

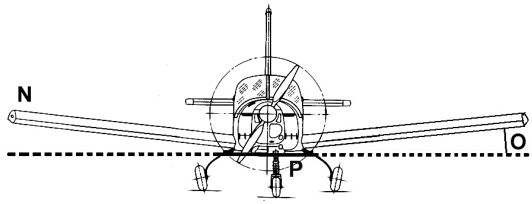



**Figure 2.3** Airfoils Seen from the Front of an Airplane

b) *Describe the significance of aspect ratio?*

c) *What types of aircraft have a high aspect ratio? What types have a low aspect ratio?*

## 2.1.2 Exercise B: Further Terminology

*Label the diagram below with the following words:*

flap main airfoil slat slot vane

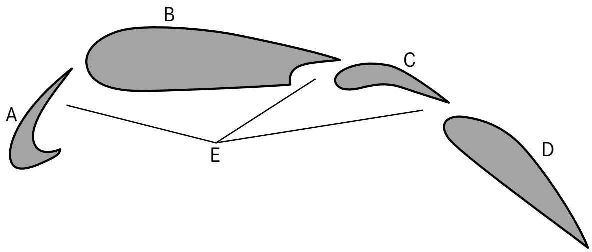



**Figure 2.4** Parts of an Airfoil

## 2.1.3 Exercise C: Swept Wings

*Describe the aerodynamic advantages and disadvantages of a swept wing over a straight wing.*

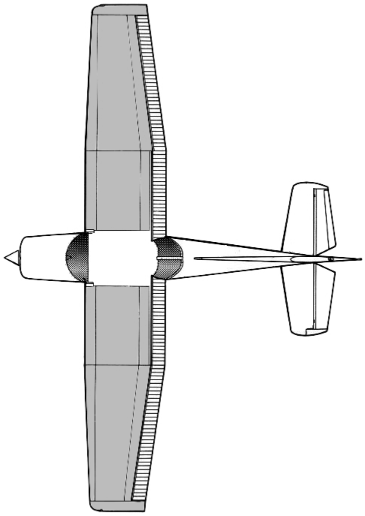


**Figure 2.5** Straight Wing

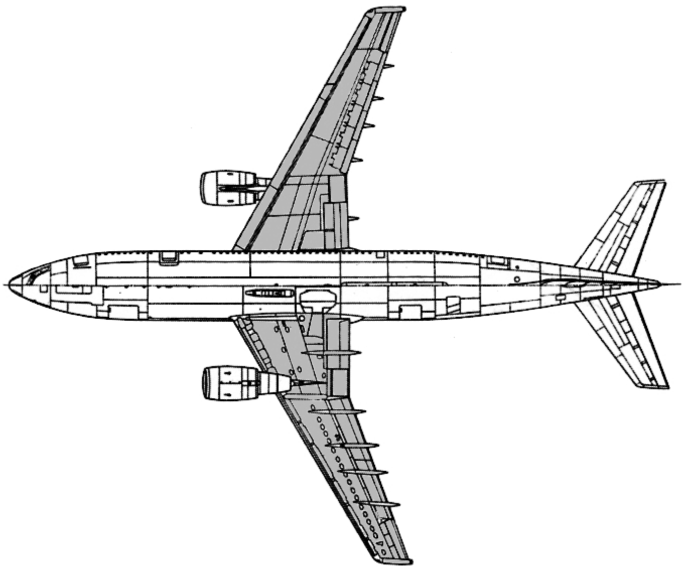


**Figure 2.6** Swept Wing

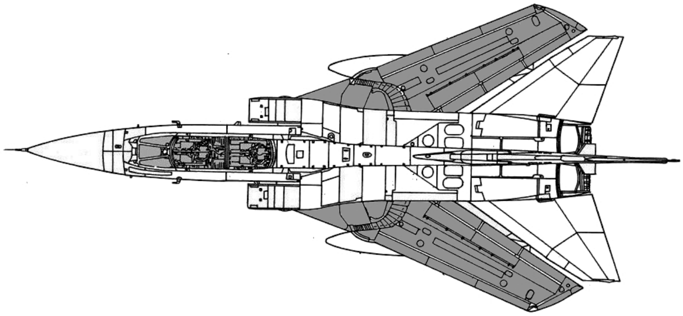


**Figure 2.7** Highly Swept Wing

## ■ 2.2 Wingtip Devices

1. In order to reduce drag and thus lower fuel consumption, aircraft engineers have looked at a number of options when it comes to wing design. Various shapes and materials have been considered with the ultimate goal of decreasing parasitic drag, the drag created while the airfoil is moving through a fluid, in this case the air. While morphing wings based on the sublime movement of an eagle might be years away, small but important changes at the wingtips of airplanes have enabled airplane manufacturers to bring aircraft to market with attractive fuel consumption levels.

2. Winglets are one such innovation. They are the upward curvature of wingtips. They effectively lengthen the wingspan whilst dampening the vortices created by induced drag, the drag that is inevitably created through the generation of lift. “An aircraft’s wing is shaped to generate negative pressure on the upper surface and positive pressure on the lower surface as the aircraft moves forward … Unequal pressure, however, also causes air at each wingtip to flow outward along the lower surface, around the tip, and inboard along the upper surface producing a whirlwind of air called a wingtip vortex.”[1]

3. Diminished vortices translate directly into cost savings and improved performance ranges for aircraft. According to Airbus, its Sharklets, which are wingtips that are curved upwards and blended into the wing without a sharp angle, yield four percent fuel savings on the longest airplane routes and can boost maximum payloads and flight ranges.[2]

---

1 *https://www.nasa.gov/centers/dryden/about/Organizations/Technology/Facts/TF-2004-15-DFRC.html*

2 *https://www.airbus.com/aircraft/support-services/upgrade-services/system-airframe-upgrades.html*