ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL TWO

INSTRUCTIONAL GUIDE

SECTION 3

EO M231.03 – DESCRIBE THE TYPES OF DRAG THAT ACT UPON AN AIRCRAFT

Total Time: 60 min

PREPARATION

PRE-LESSON INSTRUCTIONS

Resources needed for the delivery of this lesson are listed in the lesson specification located in A-CR-CCP-802/PG-001, Chapter 4. Specific uses for said resources are identified throughout the Instructional Guide within the TP for which they are required.

Review the lesson content and become familiar with the material prior to delivering the lesson.

Create presentation slides or handouts of all figures located at Annexes A to D.

PRE-LESSON ASSIGNMENT

N/A.

APPROACH

An interactive lecture was chosen for TP1, TP2 and TP4 to introduce the subject of drag and give an overview of it.

An in-class activity was chosen for TP3 and TP5 as it is an interactive way to provoke thought and stimulate an interest among cadets.

INTRODUCTION

REVIEW

Review EO M231.01 (The Four Forces That Act Upon an Aircraft), to include:

- weight,
- drag,
- thrust, and
- lift.

OBJECTIVES

By the end of this lesson the cadet shall be expected to identify and discuss the types of drag that act upon an aircraft.

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IMPORTANCE

It is important for cadets to know the types of drag that act upon an aircraft so that they will understand subsequent and related principles of flight.

Teaching point 1 **Introduce Drag as a Useful Force and Explain the Two Types of Drag**

Time: 5 min Method: Interactive Lecture

Drag is the force that opposes the forward motion of an aircraft. The two main types of drag are parasite drag and induced drag.



Show the cadets a slide or distribute handouts of drag definitions located at Annex A.

Parasite drag is caused by those parts of the aircraft that do not generate lift such as the fuselage, landing gear, struts, antennas, wing tip fuel tanks, etc. Any drag caused by openings, such as those in the cowling and those between the wing and the ailerons and flaps, add to parasite drag.

Induced drag is produced by those parts of an aircraft that are active in producing lift, such as the wings. Induced drag is the result of the wing and is therefore a part of lift and can never be eliminated.

It is true that drag does limit an aircraft's performance. However, drag also allows the pilot to control flight because an aircraft turns by increasing the drag in certain areas using control surfaces that push on the passing air. Without drag, an aircraft could not fly in a controlled manner.

CONFIRMATION OF TEACHING POINT 1

QUESTIONS

Q1. What is drag?

Q2. What causes parasite drag?

Q3. What produces induced drag?

ANTICIPATED ANSWERS

A1. Drag is the force that opposes the forward motion of an aircraft.

A2. Parasite drag is caused by those parts of the aircraft that do not generate lift.

A3. Induced drag is produced by those parts of an aircraft that are active in producing lift.

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Teaching point 2 **Define the Components of Parasite Drag**

Time: 5 min Method: Interactive Lecture



Show the cadets a slide or distribute handouts of parasite drag definitions located at Annex B.

Parasite drag is broken down into two components; form drag and skin friction:

- Form drag refers to the drag created by the form or shape of a body as it resists motion through the air.
- Skin friction refers to the tendency of air flowing over a body to cling to its surface.



Using a model aircraft with wing struts and a fixed landing gear, show the cadets parts of the aircraft that contribute to parasite drag.



Although parasite drag can never be eliminated, it can be reduced. One method is to remove parts of the aircraft that cause it. For this reason, retractable landing gears have been developed. Another method is to streamline those parts that cannot be eliminated. Skin friction can be reduced substantially by the removal of dust, dirt, mud or ice that has collected on the aircraft.

CONFIRMATION OF TEACHING POINT 2

QUESTIONS

Q1. Identify and describe the two types of parasite drag.

Q2. How do aircraft designers reduce form drag?

Q3. How do aircraft operators reduce skin friction?

ANTICIPATED ANSWERS

A1. Form drag refers to the drag created by the form or shape of a body as it resists motion through the air. Skin friction refers to the tendency of air flowing over a body to cling to its surface.

A2. Aircraft designers reduce form drag by removing or streamlining those parts of the aircraft that cause it.

A3. Aircraft operators can reduce skin friction by removing dust, dirt, mud or ice that has collected on the aircraft.

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Teaching point 3 **Demonstrate Form Drag**

Time: 15 min Method: In-Class Activity

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets fold and fly a device with greater drag on one side than the other and then to see that it always falls in the direction with the least drag.

RESOURCES

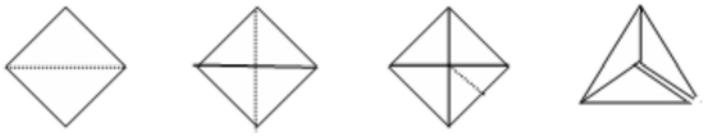
- Square paper 70 mm x 70 mm (square self-adhesive notes are ideal), and
- Tape.

ACTIVITY LAYOUT

N/A.

ACTIVITY INSTRUCTIONS

Have the cadets fold their paper squares diagonally on both diagonals from point to point and then in half vertically. The paper square can now be put into the shape of a three-sided pyramid by tucking in only the bottom area along the vertical fold. The top area of the vertical fold must be smoothed flat to remove the fold. This will produce a hollow three-sided pyramid of paper which, when dropped in any orientation, will orient itself during the fall to always land on its point.



D Cdts 3, 2007 Ottawa, ON: Department of National Defence.

Figure 1 Folding a Hollow Pyramid

Have the cadets try dropping their paper pyramids in all orientations and have them observe how the pyramids land on their points in all cases.

SAFETY

N/A.

CONFIRMATION OF TEACHING POINT 3

The cadets' participation in this activity will serve as confirmation of this TP.

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Teaching point 4 **Explain Induced Drag**

Time: 10 min Method: Interactive Lecture



Show the cadets a slide or distribute handouts of the induced drag definitions located at Annex C.

Induced drag is another force that opposes the forward motion of the aircraft, but it is produced by those parts of an aircraft that are active in producing lift. Induced drag results from the wing and is therefore a part of lift that can never be eliminated.



Induced drag increases as the angle of attack increases and decreases as the angle of attack decreases.

Induced drag can only be reduced during the initial designing of the aircraft. The phenomenon known as wing tip vortices seen in Figure D-1 is testimony to the existence of induced drag.



Show the cadets a slide or distribute handouts of the aircraft shown in Figure D-1.

Point out the wing tip vortices.

Aircraft are often fixed with upwardly swept wing tip “winglets” to reduce wing tip vortices and their associated induced drag as shown in Figure D-2.

The various forms of drag change with different flying conditions and, in general, they increase with speed. As well, when the pilot uses control surfaces, they produce both form drag and induced drag.



Cadets interested in further reading can read the explanation of wing tip vortices in A-CR-CCP-263/PT-001, *From the Ground Up: Millennium Edition*, in the section on induced drag.

CONFIRMATION OF TEACHING POINT 4

QUESTIONS

Q1. What is the relationship between angle of attack and induced drag?

Q2. When is the optimum time to minimize induced drag?

Q3. What is the relationship between drag and air speed?

ANTICIPATED ANSWERS

A1. Induced drag increases as the angle of attack increases and induced drag decreases as the angle of attack decreases.

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A2. During the design of the aircraft.

A3. Drag tends to increase with increasing speed.

Teaching point 5 **Demonstrate Induced Drag**

Time: 20 min Method: In-Class Activity

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets experience the sensation of induced drag.

RESOURCES

- Bristol board,
- Tape, and
- Fan.

ACTIVITY LAYOUT

N/A.

ACTIVITY INSTRUCTIONS

Create a wing-like surface by taping together two pieces of Bristol board 50 cm square. Tape only three sides so that the cadet can put one hand inside this “wing”.

Turn on the fan. Have each cadet place a hand in the wing below the fan and slowly raise the wing toward the moving air, using only a very slight angle of attack. In addition to the feeling of lift into the moving air, the cadet will also sense the backward pull of induced drag just before the stronger push of form drag is experienced.

SAFETY

N/A.

CONFIRMATION OF TEACHING POINT 5

The cadets’ participation in the activity will serve as the confirmation of this TP.

END OF LESSON CONFIRMATION

QUESTIONS

Q1. What are the main types of drag?

Q2. What causes parasite drag?

Q3. What is the relationship between angle of attack and induced drag?

ANTICIPATED ANSWERS

A1. The main types of drag are parasite drag and induced drag.

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A2. Parasite drag is caused by those parts of the aircraft that do not generate lift.

A3. Induced drag increases as the angle of attack increases and induced drag decreases as the angle of attack decreases.

CONCLUSION

HOMEWORK/READING/PRACTICE

N/A.

METHOD OF EVALUATION

N/A.

CLOSING STATEMENT

Understanding drag is important because drag affects both the design and performance of aircraft.

INSTRUCTOR NOTES/REMARKS

N/A.

REFERENCES

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C3-058 (ISBN 1-4027-3034-9) Schmidt, N. (2005). *Paper Creations Paper Airplanes.* New York, NY. Sterling Publishing.

C3-092 (ISBN 0-7460-0978-X) Edom, H., Butterfield, M., Heddle, R. and Unwin, M. (1992). *The Usborne Book of Science Activities: Volume Two.* Tulsa OK: EDC Publishing.

C3-116 A-CR-CCP-263/PT-001/(ISBN 0-9680390-5-7) MacDonald, A. F. and Peppler, I. L. (2000). *From the Ground Up: Millennium Edition.* Ottawa, ON: Aviation Publishers Co. Limited.

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DRAG DEFINITIONS

DRAG IS THE FORCE THAT OPPOSES THE FORWARD MOTION OF AN AIRCRAFT.

- THE TWO MAIN TYPES OF DRAG ARE **PARASITE DRAG** AND **INDUCED DRAG**.

- PARASITE DRAG IS FURTHER BROKEN INTO TWO TYPES, **FORM DRAG** AND **SKIN FRICTION**.

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PARASITE DRAG DEFINITIONS

PARASITE DRAG

PARASITE DRAG IS THE DRAG PRODUCED BY THOSE PARTS OF THE AIRCRAFT THAT **DO NOT** CONTRIBUTE TO THE PRODUCTION OF LIFT.

- **FORM DRAG** REFERS TO THE DRAG CREATED BY THE SHAPE OF A BODY AS IT RESISTS MOTION THROUGH THE AIR.

- **SKIN FRICTION** REFERS TO THE TENDENCY OF AIR FLOWING OVER A BODY TO CLING TO ITS SURFACE.

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INDUCED DRAG DEFINITIONS

INDUCED DRAG

- INDUCED DRAG IS THE DRAG PRODUCED BY THOSE PARTS OF THE AIRCRAFT THAT **ARE ACTIVE** IN THE PRODUCTION OF LIFT.

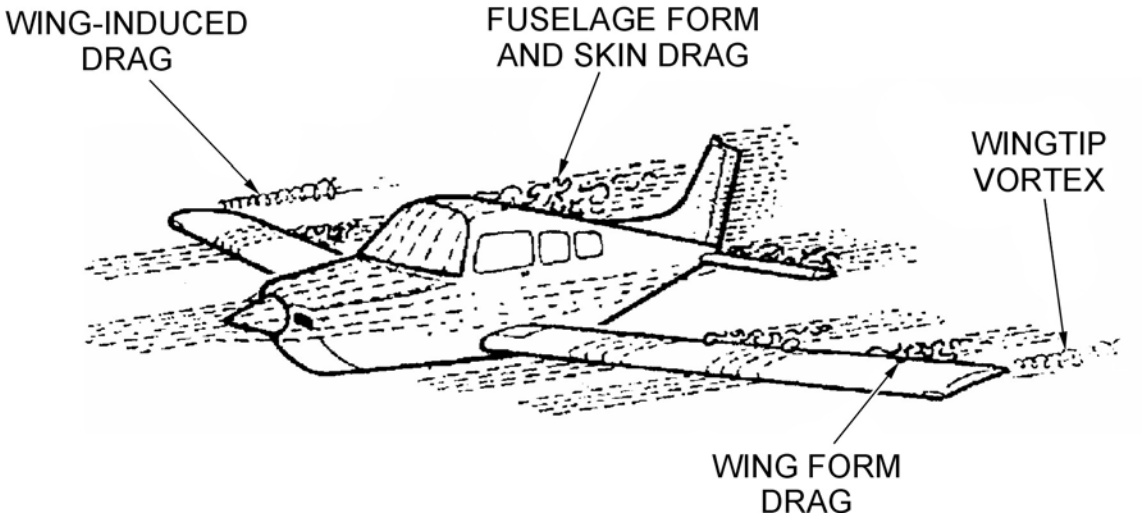
- IT IS THE RESULT OF THE WING'S WORK AND THEREFORE A PART OF LIFT AND CAN NEVER BE ELIMINATED.

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TYPES OF DRAG

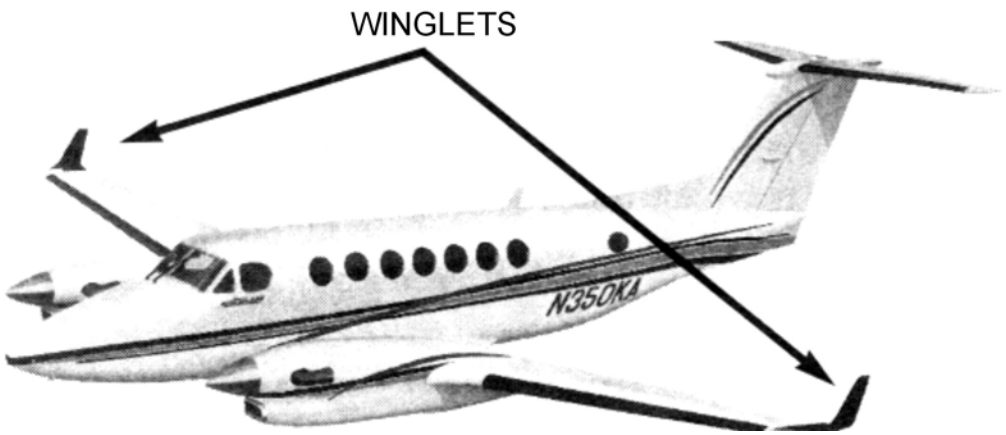


Cadets Canada: RCSU Pacific, 2007, Air Cadet Master Lesson Plans. Retrieved 7 March 2007, from http://www.regions.cadets.ca/pac/aircad/resources/mlp_air_e.asp

Figure D-1 Types of Drag on an Aircraft

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PREVENTING WING TIP VORTICES



A-CR-CCP-263/PT-001 (p. 27)

Figure D-2 Winglets

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