ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL THREE

INSTRUCTIONAL GUIDE

SECTION 4

EO C331.03 – IDENTIFY ASPECTS OF HELICOPTER AERODYNAMICS

Total Time: 30 min

PREPARATION

PRE-LESSON INSTRUCTIONS

Resources needed for the delivery of this lesson are listed in the lesson specification located in A-CR-CCP-803/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 slides of Annexes L and M.

Bring a model helicopter to class. If possible use a radio-controlled helicopter to illustrate helicopter aerodynamics.

PRE-LESSON ASSIGNMENT

N/A.

APPROACH

An interactive lecture was chosen for this lesson to introduce the cadets to aspects of helicopter aerodynamics.

INTRODUCTION

REVIEW

N/A.

OBJECTIVES

By the end of this lesson the cadet shall be expected to identify aspects of helicopter aerodynamics.

IMPORTANCE

It is important for cadets to identify aspects of helicopter aerodynamics so that they can appreciate the differences between airplanes and helicopters.

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Teaching point 1 **Describe the Main Rotor of a Helicopter**

Time: 15 min Method: Interactive Lecture

THE MAIN ROTOR OF A HELICOPTER

Helicopters, like airplanes, have airfoils. Unlike airplanes, which have fixed airfoils (wings), the airfoils of a helicopter are not in a fixed position. The airfoils on a helicopter are called rotor blades, which are attached to a rotating point on the top of the helicopter's airframe. The whole assembly is referred to as the main rotor or rotor system.

The terms "fixed wing" (airplane) and "rotary wing" (helicopter) are derived from the physical differences between airplane and helicopter airfoils.



Use the model of the helicopter to illustrate each of the following points. If possible, a radio-controlled helicopter model should be used as it will dynamically illustrate the concepts of rotor thrust and rotor drag.

Rotor Systems

The rotor systems of a helicopter incorporate many parts. Three of the basic parts are:

- the rotor blades,
- the rotor head, and
- the drive shaft.

The rotor blades are attached to the rotor head. The rotor head sits on top of the drive shaft. As the drive shaft spins, it moves the blades through the air.

As the blades spin, they act like the wings of an airplane. The shape of the rotor blade is symmetrical, meaning that the top of the blade is shaped the same as the bottom of the blade. As each blade passes through the air, the airflow over the blade creates lift using the same principles of a wing.

In order for a helicopter to move in a horizontal direction, the rotor system must be angled in the direction of travel. This changes the angle of the plane in which the blades rotate, and the rotor blades act the same as propellers.

Flying a helicopter is complicated. Once the angle of the plane of rotation has been changed, the amount of lift being produced will no longer be enough to maintain the helicopter's altitude. The pilot must apply more power in order to counteract this. The total lift force required to maintain the helicopter's altitude and forward motion is referred to as total rotor thrust.

Rotor Drag

Rotor drag is the opposite of rotor thrust. It is commonly known as torque, and acts opposite to the direction that each blade travels. Rotor drag attempts to slow down the rotation of the blades and an increase in engine power is required to maintain the speed of the blades. If the force of rotor drag is stronger than the rotor thrust, then the torque causes the body of the helicopter to rotate instead of the blades.

Rotor drag should not be confused with aerodynamic drag.

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Aerodynamic drag is a force that acts on the body of the aircraft as it moves through the air. It acts opposite to thrust (see the four forces acting on an aircraft).

Factors Influencing Rotor Thrust

There are four factors that influence rotor thrust, including:

- **Air Density.** As the rotor blades pass through the air, the reaction between the air molecules and the surface of the blade produces lift. More air molecules will create a stronger reaction. One may state that more lift is produced in higher density air vice lower density air because dense air has more molecules. Air density can decrease with increases in temperature or decreases in pressure.
- **Rotor Revolutions per Minute (rpm).** An increase in rotor rpm increases the total rotor thrust, while a decrease in rotor rpm decreases the total rotor thrust.
- **Blade (Pitch) Angle.** An increase in the blade angle increases the total rotor thrust, while a decrease in the blade angle decreases the total rotor thrust. This is similar to the effects of pitch on an airplane's wings.
- **Disc Area.** Disc area is the total area in which the rotor blades rotate and is determined by the length of the rotor blades. The larger the disc area is, the higher the total rotor thrust will be. This follows the same principle with airplanes, where the larger the wing area, the more lift is produced.

CONFIRMATION OF TEACHING POINT 1

QUESTIONS

Q1. What are the three basic parts of a rotor system?

Q2. Which force acts opposite to rotor thrust?

Q3. How does disc area influence rotor thrust?

ANTICIPATED ANSWERS

A1. The rotor blades, rotor head, and drive shaft.

A2. Rotor drag.

A3. The larger the disc area is, the higher the total rotor thrust will be.

Teaching point 2 **Describe the Anti-Torque Rotor of a Helicopter**

Time: 5 min Method: Interactive Lecture

THE ANTI-TORQUE ROTOR



Show slide of Annex L.

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Location on the Airframe

The anti-torque rotor is a smaller version of the main rotor. It is mounted vertically at the end of the tail. Most helicopters have an anti-torque rotor that sits in the right side of the tail, although some designs have the anti-torque rotor mounted on the left side or built into the tail assembly.



Airforce Imagery, 2008, CH-149 Cyclone. Copyright 2006 by Sikorsky Aircraft Corporation. Retrieved April 9, 2008, from http://www.airforceimagery.forces.gc.ca/netpub/server.np?find&catalog=casimages&template=detail2_e.np&field=itemid&op=matches&value=3018&site=casimages

Figure 1 Location of Anti-Torque Rotor

Function

The function of the anti-torque rotor is to counteract the torque produced by the main rotor. Without the anti-torque rotor, the rotation of the main rotor would transfer to the airframe and rotate the airframe instead of the rotor blades. By installing the anti-torque rotor, the airframe stays relatively still while the rotor blades rotate above the airframe. The anti-torque rotor serves to control movement around the vertical axis of the helicopter.

Power Source

The anti-torque rotor receives power from the main engine through a drive shaft which runs the length of the tail assembly.

CONFIRMATION OF TEACHING POINT 2

QUESTIONS

Q1. Where is the anti-torque rotor normally located?

Q2. What are the functions of the anti-torque rotor?

Q3. How does the anti-torque rotor receive power?

ANTICIPATED ANSWERS

A1. It is mounted vertically at the end of the tail.

A2. The functions of the anti-torque rotor are to counteract the torque produced by the main rotor and to control movement around the vertical axis.

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A3. The anti-torque rotor receives power from the main engine through a drive shaft, which runs the length of the tail assembly.

Teaching point 3 **Explain the Control Inputs of a Helicopter**

Time: 5 min Method: Interactive Lecture

CONTROL INPUTS OF A HELICOPTER

There are three primary control inputs of a helicopter. They differ from the control inputs of an airplane in some ways, but are similar in others. The three primary control inputs are:

- collective,
- cyclic, and
- pedals.



Show slide of Annex M.

Collective

The collective is an arm lever located on the left side of the pilot's seat (in most helicopters the pilot sits on the right side of the cockpit). The collective controls the angle of attack of the rotor blades which will affect the amount of lift produced. Pulling up on the collective will increase the angle of attack, producing more lift. Pushing down on the collective will decrease the angle of attack, producing less lift.

At the end of the collective is a throttle. The throttle on a helicopter is a twist-style grip. The throttle controls the rpm of the blades. An increase in rpm will increase the amount of lift produced and the speed at which the helicopter travels.

It is important to remember that the rotors act in the same way as both the wings and the propeller of an airplane. They produce the lift and the thrust. The same happens for movements forward, backward and to the right.

Cyclic

In a helicopter, the control column is known as the cyclic. The cyclic controls the angle of the plane in which the rotor blades move. Moving the cyclic left will angle the rotation of the blades left. Maintaining that angle long enough will move the helicopter to the left.

Pedals

The pedals in a helicopter cockpit are similar to rudder pedals. They control the anti-torque rotor, providing directional stability. They also control which direction the nose of the helicopter is pointed. One of the unique capabilities of a helicopter is that the nose can be pointed in a different direction than the direction of travel. This provides the helicopter increased manoeuvrability.

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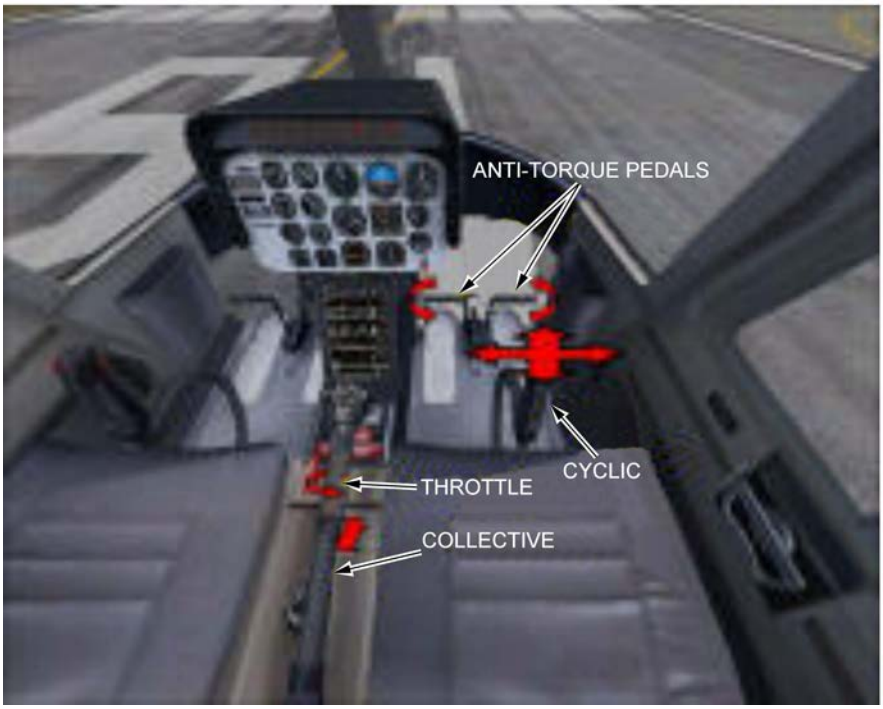

AVSIM Online, by S. Cartwright, 2004, Helicopter Tutorial. Copyright 2004 by AVSIM Online. Retrieved April 8, 2008, from http://www.avsim.com/pages/0604/heli/helitutorial.htm

Figure 2 Helicopter Control Inputs

CONFIRMATION OF TEACHING POINT 3

QUESTIONS

Q1. What does the collective control?

Q2. What does the cyclic control?

Q3. What do the pedals control?

ANTICIPATED ANSWERS

A1. The angle of attack of the rotor blades.

A2. The angle of the plane in which the rotor blades move.

A3. They control the anti-torque rotor, providing directional stability. They also control which direction the nose of the helicopter is pointed.

END OF LESSON CONFIRMATION

QUESTIONS

Q1. How do the main rotor systems produce lift?

Q2. What is the function of the anti-torque rotor?

Q3. What is one of the unique capabilities of helicopters?

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ANTICIPATED ANSWERS

A1. As each blade passes through the air, the airflow over the blade creates lift using the same principles as a wing.

A2. The function of the anti-torque rotor is to counteract the torque produced by the main rotor.

A3. One of the unique capabilities of a helicopter is that the nose can be pointed in a different direction than the direction of travel.

CONCLUSION

HOMEWORK/READING/PRACTICE

N/A.

METHOD OF EVALUATION

N/A.

CLOSING STATEMENT

Helicopters are flown using very different applications of Newtonian physics. Certain parts of the helicopter are similar to airplanes but have different functions. These differences make the helicopter a more manoeuvrable aircraft and more challenging to fly.

INSTRUCTOR NOTES/REMARKS

It is recommended that this EO be scheduled with EO C331.05 (Tour a Local Aviation Facility, A-CR-CCP-803/PG-001, Chapter 4, Section 13) if helicopters are present at the facility.

If the squadron has the opportunity to participate in familiarization flights in a helicopter, this EO should be conducted at that time.

REFERENCES

C3-249 (ISBN 978-1-56027-649-4) Wagtendok, W. J. (2006). *Principles of Helicopter Flight: Second US Edition*. Newcastle, WA: Aviation Supplies & Academics, Inc.

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