ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL THREE

INSTRUCTIONAL GUIDE

SECTION 1

EO M331.01 – DESCRIBE AIRCRAFT STABILITY

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-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.

Set up the four stations as described in Annex A.

Create slide of Annex B.

PRE-LESSON ASSIGNMENT

N/A.

APPROACH

An in-class activity was chosen for TP 1 as it is an interactive way to introduce aircraft stability.

An interactive lecture was chosen for TPs 2–5 to review axes of rotation and introduce stability about the axes.

INTRODUCTION

REVIEW

N/A.

OBJECTIVES

By the end of this lesson the cadet shall have described aircraft stability.

IMPORTANCE

It is important for cadets to describe aircraft stability so that they understand why aircraft are designed with certain features. Cadets will also understand how an aircraft will react when flying through turbulent weather or when it is put through aggressive manoeuvres.

Teaching Point 1 | **Demonstrate the Characteristics of Stability**

Time: 15 min | Method: In-Class Activity

CHARACTERISTICS OF STABILITY

Stability. The tendency of an aircraft in flight to remain in straight, level, upright flight and to return to this attitude, if displaced, without corrective action by the pilot.

Static Stability. The initial tendency of an aircraft to return to its original attitude, if displaced.

Dynamic Stability. The overall tendency of an aircraft to return to its original attitude.

Positive Stability. The aircraft is able to return to its original attitude without any corrective measure.

Neutral Stability. The aircraft will remain in the new attitude of flight after being displaced, neither returning to its original attitude, nor continuing to move away.

Negative Stability. The aircraft will continue moving away from its original attitude after being displaced.

ACTIVITY

Time: 10 min

OBJECTIVE

The objective of this activity is to provide a tactile method of illustrating the different types of aircraft stability.

RESOURCES

- Tennis ball,
- Three marbles,
- Table,
- Tape, and
- Two bowls.

ACTIVITY LAYOUT

Set up four stations IAW Annex A.

ACTIVITY INSTRUCTIONS

1. Divide the cadets into four groups of equal size.
2. Assign each group to a station.
3. Have each group perform the activity at each station.
4. After the cadets have been to all stations, ask the cadets what they observed.

SAFETY

N/A.

CONFIRMATION OF TEACHING POINT 1

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

Teaching Point 2	**Review the Axes of an Aircraft**
Time: 10 min	Method: Interactive Lecture

AXES OF THE AIRCRAFT

> Present the slide located at Annex B to the cadets.
>
> Demonstrate each axis with the model aircraft.

Each axis is an imaginary straight line which runs through the aircraft in a particular direction. All three axes intersect at the centre of gravity.

> Ask the cadets what the three axes of an aircraft are.

Longitudinal Axis and Roll

This axis runs the length of the aircraft from the tip of the nose to the end of the empennage. Movement around this axis is roll.

> Ask the cadets which control surface controls roll.

Lateral Axis and Pitch

This axis runs through the aircrafts' wings, from wing tip to wing tip. Movement around this axis is pitch.

> Ask the cadets which control surface controls pitch.

Normal (Vertical) Axis and Yaw

This axis runs through the aircraft vertically top to bottom. Movement about this axis is yaw.

Ask the cadets which control surface controls yaw.

Have the cadets make a paper airplane, marking each of the axes. Have them hold their airplanes in the air while you call out a movement (eg, roll) which they will demonstrate individually using their airplanes.

CONFIRMATION OF TEACHING POINT 2

The cadets' participation in the paper airplane activity will serve as the confirmation of this lesson.

Teaching Point 3	**Explain Longitudinal Stability**
Time: 10 min	Method: Interactive Lecture

LONGITUDINAL STABILITY

Longitudinal stability is stability around the lateral axis and is known as pitch stability. To achieve longitudinal stability, aircraft are designed to be nose heavy if loaded correctly.

Two principle factors influence longitudinal stability:

- the horizontal stabilizer, and
- the centre of gravity.

The Effects of the Horizontal Stabilizer

The horizontal stabilizer is located at the tail end of the aircraft. Its function is similar to a counterweight at the end of a lever. When the nose of the aircraft is pushed up, this will force the tail down. Since the stabilizer now meets the airflow at a higher angle of attack, it will now produce more lift. This extra lift will counter the initial disturbance.

Use the model airplane to demonstrate the effects of the horizontal stabilizer.

The Effects of the Centre of Gravity

The centre of gravity is an important factor in aircraft stability. Every aircraft has a naturally occurring centre of gravity which is inherent in its design. As the aircraft is loaded, the position of the centre of gravity can change. If this change is drastic, it can have an adverse affect on the stability of an aircraft.

> Use the model airplane to demonstrate a forward centre of gravity.

If the centre of gravity is too far forward, it will produce a nose-down tendency. This will force the pilot to use excessive back pressure on the controls to maintain normal flight. If left uncorrected, the aircraft will speed up and lose altitude.

If the centre of gravity is too far aft, it will produce a nose-up tendency. This will force the pilot to use excessive forward pressure on the controls to maintain normal flight. Uncorrected, the aircraft will slow down and eventually stall.

> Use the model airplane to demonstrate an aft centre of gravity.

CONFIRMATION OF TEACHING POINT 3

QUESTIONS

Q1. What is longitudinal stability?

Q2. What does the horizontal stabilizer act like?

Q3. What is the danger of an aft centre of gravity?

ANTICIPATED ANSWERS

A1. Stability around the lateral axis.

A2. A counterweight at the end of a lever.

A3. Stall.

Teaching Point 4	**Explain Lateral Stability**
Time: 10 min	Method: Interactive Lecture

LATERAL STABILITY

Lateral stability is stability around the longitudinal axis and is called roll stability. To achieve lateral stability certain design features are built into the aircraft. Three of these design features are:

- dihedral,
- sweepback, and
- keel effect.

The Effects of Dihedral and Anhedral

Dihedral is the angle that the wings make with the horizontal plane. As one looks at an aircraft from the front, the wings will slowly angle away from the ground so that the wing tip is higher than the wing root.

This assists the aircraft in maintaining lateral stability by changing the angle that the leading edge makes with the airflow.

When an aircraft with dihedral wings is forced in to a side-slipping motion, the down-going wing will meet the airflow at a right angle. This will increase the lift produced on that wing, forcing it back into place.

Use the model airplane to demonstrate dihedral.

Some aircraft have been designed with a negative dihedral, also known as anhedral. Anhedral acts opposite to dihedral, creating less stability. Usually found in aircraft with both sweepback and keel effect.

The Effects of Sweepback

Similar to the dihedral, sweepback is a design feature where the wings sweep back instead of protruding straight out from the fuselage.

This assists the aircraft in maintaining lateral stability by changing the angle that the leading edge makes with the airflow.

When an aircraft with sweepback is forced into a slipping motion, the down going wing will meet the airflow at a right angle. This will increase the lift produced by that wing forcing it back into place.

Use the model airplane to demonstrate sweepback.

Keel Effect

While dihedral and sweepback are usually found on low-wing aircraft, high-wing aircraft have stability built-in. Since the bulk of the aircraft is below the plane of the wings, it acts as a keel. When a wing is forced up by a disturbance, the fuselage acts like a pendulum swinging the aircraft back into position.

Use the model airplane to demonstrate keel effect.

CONFIRMATION OF TEACHING POINT 4

QUESTIONS

Q1. What is lateral stability?

Q2. What are three design features which provide lateral stability?

Q3. How does keel effect work?

ANTICIPATED ANSWERS

A1. Lateral stability is stability around the longitudinal axis.

A2. Dihedral, sweepback, and keel effect.

A3. When a wing is forced up by a disturbance, the fuselage acts like a pendulum swinging the aircraft back into position.

Teaching Point 5	**Explain Directional Stability and the Effects of the Fin**
Time: 5 min	Method: Interactive Lecture

DIRECTIONAL STABILITY

Directional stability is stability around the vertical or normal axis. The principle factor influencing directional stability is the vertical tail surface, or fin.

The Effects of the Fin

Aircraft, specifically airplanes, have a tendency of always flying head-on into the relative airflow. This tendency, called weather vaning, is a direct result of the vertical tail fin. If the aircraft yaws away from its course, the airflow strikes the fin from the side, forcing it back into position.

This will only work if the side area of the aircraft is greater aft of the centre of gravity than the area forward of the centre of gravity.

Use the model airplane to demonstrate the effects of the fin.

CONFIRMATION OF TEACHING POINT 5

QUESTIONS

Q1. What is directional stability?

Q2. What is the principle factor influencing directional stability?

Q3. What is the effect of the fin?

ANTICIPATED ANSWERS

A1. Directional stability is stability around the vertical or normal axis.

A2. The principle factor influencing directional stability is the vertical tail surface, or fin.

A3. If the airplane yaws away from its course, the airflow strikes the fin from the side, forcing it back into position.

END OF LESSON CONFIRMATION

QUESTIONS

Q1. What is dynamic stability?

Q2. What is the danger of an aft centre of gravity?

Q3. What are three design features which provide lateral stability?

ANTICIPATED ANSWERS

A1. The overall tendency of an aircraft to return to its original position.

A2. Stall.

A3. Dihedral, sweepback, and keel effect.

CONCLUSION

HOMEWORK/READING/PRACTICE

N/A.

METHOD OF EVALUATION

This EO is assessed IAW Chapter 3, Annex B, Aviation Subjects–Combined Assessment PC.

CLOSING STATEMENT

Aircraft, airplanes in particular, require a lot of stability in order to operate safely. All airplanes have stability designed into them. Commercial and private airplanes tend to have positive stability, while military fighters tend to have neutral or negative stability.

INSTRUCTOR NOTES/REMARKS

If EO C331.01 (Review Principles of Flight, Section 2) is chosen as a complementary period, it should be scheduled prior to this EO.

When developing activities for the mandatory familiarization flying/elemental training day, it is recommended that the cadet be given the opportunity to identify and describe the stability of the aircraft.

REFERENCES

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

C3-229 (ISBN 0-521-02128-6) Abzug, M. J., & Larrabee, E. E. (2002). *Airplane Stability and Control* (Second Edition). Cambridge, England: Cambridge University Press.