ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL FOUR

INSTRUCTIONAL GUIDE

SECTION 2

EO M432.02 – DESCRIBE PROPELLER SYSTEMS

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-804/PG-001, *Proficiency Level Four Qualification Standard and Plan*, 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.

Prepare slides located at Attachment A.

PRE-LESSON ASSIGNMENT

Nil.

APPROACH

An interactive lecture was chosen for this lesson to clarify, emphasize, and summarize propeller systems.

INTRODUCTION

REVIEW

Nil.

OBJECTIVES

By the end of this lesson the cadet shall have described propeller systems.

IMPORTANCE

It is important for cadets to be able to describe propeller systems as a solid understanding of propeller systems provides knowledge for potential instructional duties and is part of the fundamentals that cadets pursuing future aviation training will require.

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Teaching point 1 **Describe propeller systems.**

Time: 10 min Method: Interactive Lecture

The propeller provides the necessary thrust to pull, or in some cases push, the airplane through the air. The engine power rotates the propeller that generates thrust very similar to the manner in which a wing produces lift.

The propeller is a rotating airfoil designed to push air backward as it moves forward along a corkscrew (helical) path. It meets the air at an angle of attack as it rotates, producing thrust (lift) and torque (drag).

Propeller torque is different than engine crankshaft torque in that propeller torque is drag. It is the resistance to the blades as they rotate, resulting in a tendency in the aircraft to roll in a direction opposite to the rotation of the propeller. Engine crankshaft torque is the turning moment produced at the crankshaft. When the propeller is revolving at a constant rpm, propeller torque and engine torque will be exactly equal and opposite.



Show slide of Figure A-1 to the cadets.

A typical propeller is twisted so the blade angles and tapers from the hub to the tip. The highest angle of incidence (pitch) is at the hub and the smallest pitch is at the tip.



Show slide of Figure A-2 to the cadets.

By means of the variation in airfoil sections and the angle of attack, uniform thrust is maintained throughout most of the diameter of the propeller.



Show slide of Figure A-3 to the cadets.

Tractors are propellers attached forward of the engine that pull from the front of the aircraft.

Pushers are propellers attached aft of the engine that push from behind the aircraft.

Pitch. The distance in feet a propeller travels forward in one revolution. Propeller pitch is the difference between theoretical pitch (geometric pitch) and practical pitch (effective pitch).

Theoretical pitch. The distance travelled forward in one revolution if the propeller was working in a perfect fluid. This depends on the blade angle and diameter of the propeller.

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Practical pitch. The distance the propeller travels in air in one revolution. The forward motion is less than theoretical pitch.

The angle of the blade, like the angle of incidence of a wing, governs the pitch. The propeller set in coarse pitch will travel a greater distance with each revolution. The aircraft will move forward at greater speed for a given rpm.

The propeller set in fine pitch will have less torque (drag) and will revolve at a higher speed around its axis. The engine will produce greater power. A fine pitch propeller will be good for taking off and climbing but a coarse pitch propeller will develop high cruise speed with comparatively low engine rpm giving good fuel economy.

CONFIRMATION OF TEACHING POINT 1

QUESTIONS:

Q1. What does the propeller provide?

Q2. What is propeller torque?

Q3. For what is a fine pitch propeller good?

ANTICIPATED ANSWERS:

A1. The propeller provides the necessary thrust to pull, or in some cases push, the airplane through the air.

A2. It is the resistance to the blades as they rotate, resulting in a tendency in the aircraft to roll in a direction opposite to the rotation of the propeller.

A3. A fine pitch propeller will be good for taking off and climbing.

Teaching point 2 **Describe types of propellers.**

Time: 10 min Method: Interactive Lecture

FIXED PITCH PROPELLERS

Fixed pitch propeller. The blade angle can not be adjusted by the pilot and is used on most training aircraft. The blade angle is set by the manufacturer to provide the best compromise for all flight conditions.

VARIABLE PITCH PROPELLERS

Adjustable pitch propeller. The blade angle can be changed on the ground to adjust for the varying flight situations such as changed takeoff and climb needs.

Controllable pitch propeller. The blade angles can be adjusted by the pilot during flight. The propeller set in a fine pitch for takeoff allows the engine to develop maximum power. The propeller is then adjusted to a coarse pitch to accelerate at a rapid rate to the desired cruise speed.

Constant speed propeller. The blade angles automatically adjust themselves to maintain a constant rpm as set by the pilot.

The mechanism for adjusting the pitch of the propeller includes:

- mechanical,
- hydraulic, and
- electrical.

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Mechanical variable pitch propeller. The pilot adjusts this type of propeller by a control on the instrument panel. The control is directly linked to the propeller which has stop sets to govern the blade angle and travel.

Hydraulic variable pitch propellers. A hydraulically operated cylinder pushes or pulls on a cam connected to gears on the propeller blade. The mechanism can be a counterweight or hydromatic.

The counterweight relies on oil pressure to move the cylinder that twists the blades of a controllable pitch propeller toward fine pitch. The control is adjusted by the pilot in the cockpit.

A constant pitch propeller uses the oil pressure and counterweight principle to twist the blades to the proper pitch angle to maintain a constant rpm. The pilot uses the throttle and propeller control located in the cockpit. The throttle controls the power output of the engine and the propeller control regulates the rpm of both the propeller and the engine.



If oil pressure is lost during flight, the propeller will automatically go into an extreme coarse pitch position where the blades are streamlined and cease to turn (feathered). This system is used in multi-engine aircraft.

A powerful force called centrifugal twisting moment turns the blades toward the fine pitch position of a hydromatic constant speed propeller. The natural force eliminates the use of counterweights. Oil enters the piston chamber under high pressure which moves the piston aft and the blades move into coarse pitch. When the oil enters into the piston chamber under engine pressure, the blades move to fine pitch.



If oil pressure is lost during flight, the propeller will automatically go into fine pitch position, enabling the engine to develop the most power it can and achieve the best performance under the circumstances. This system is used in single-engine aircraft.

Electric variable pitch propellers. An electrical motor turns the blades through a gear speed reducer and bevel gears for an electrical variable pitch propeller. Flyweights open and close electric circuits. One circuit causes a right-hand rotation of the motor and another causes a left-hand rotation. The rotation of the motor will adjust the blades toward a fine or coarse pitch as required. The pilot can set a two-way switch to either manual or automatic operation.

CONFIRMATION OF TEACHING POINT 2

QUESTIONS:

Q1. Who sets the blade angle on fixed pitch propeller?

Q2. How can the propeller pitch be adjusted?

Q3. What happens to the propeller if oil pressure is lost on a single-engine aircraft?

ANTICIPATED ANSWERS:

A1. The blade angle is set by the manufacturer.

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A2. The mechanism for adjusting the pitch of the propeller includes:

- mechanical,
- hydraulic, and
- electrical.

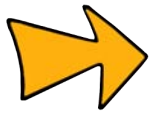
A3. If oil pressure is lost during flight, the propeller will automatically go into fine pitch position, enabling the engine to develop the most power it can and achieve the best performance under the circumstances.

Teaching point 3 **Describe feathering and propeller reversing.**

Time: 5 min Method: Interactive Lecture

Feathering is used on multi-engine aircraft. When one engine is off, the propeller is feathered meaning the turning blades are the extreme coarse pitch position and stop turning. This reduces drag on the blades, possible damage to the defective engine and stops excessive vibration.

Propeller reversing is used at slow speed to assist with stopping an aircraft once on the ground. The blade angle of a controllable pitch propeller is changed to a negative value. The reverse pitch uses engine power to produce a high negative thrust at slow speed.



A pilot of a multi-engine aircraft can decrease the radius of a turn by using propeller reversing with the inside engine.

CONFIRMATION OF TEACHING POINT 3

QUESTIONS:

Q1. What is feathering?

Q2. For what is propeller reversing used?

Q3. What pitch angle is used during propeller reversing?

ANTICIPATED ANSWERS:

A1. Feathering is when blades are set to the extreme coarse pitch position and stop turning.

A2. Propeller reversing is used at slow speed to assist with stopping an aircraft once on the ground.

A3. A negative pitch angle is used during propeller reversing.

END OF LESSON CONFIRMATION

QUESTIONS:

Q1. What is pitch?

Q2. Name two propeller types.

Q3. What type of aircraft use propeller feathering?

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ANTICIPATED ANSWERS:

A1. Pitch is the distance in feet a propeller travels forward in one revolution.

A2. Fixed pitch and variable pitch.

A3. Multi-engine aircraft.

CONCLUSION

HOMEWORK / READING / PRACTICE

Nil.

METHOD OF EVALUATION

This EO is assessed IAW A-CR-CCP-804/PG-001, *Proficiency Level Four Qualification Standard and Plan*, Chapter 3, Annex B, Aviation Subjects–Combined Assessment PC.

CLOSING STATEMENT

Being able to describe propeller systems is important for understanding more complex material. A solid understanding of propellers is required to pursue future aviation training.

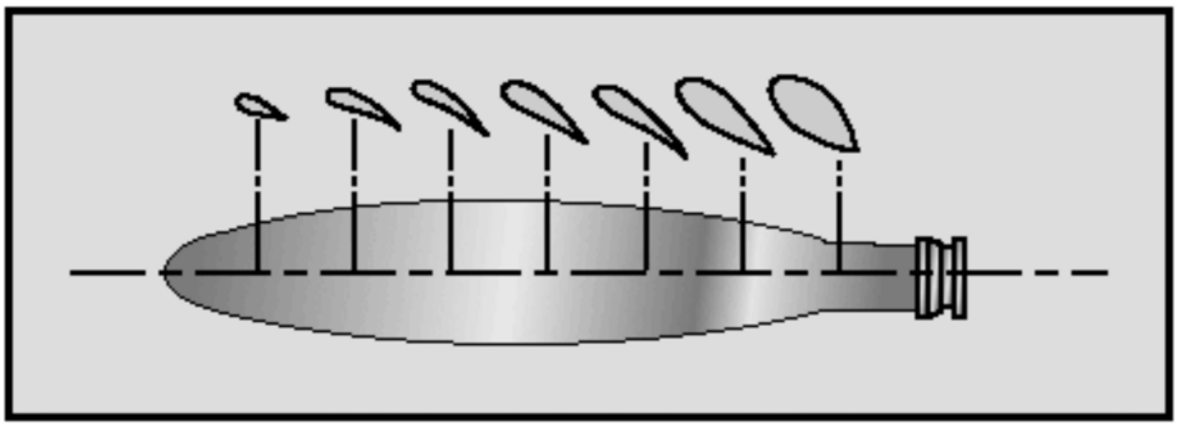
INSTRUCTOR NOTES / REMARKS

Nil.

REFERENCES

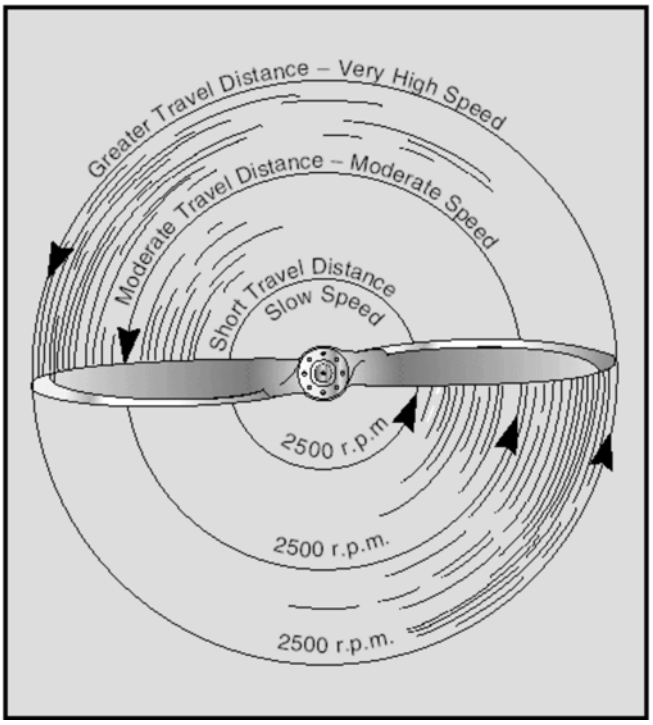
C3-116 ISBN 0-9680390-5-7 MacDonald, A. F., & Peppler, I. L. (2000). *From the ground up: Millennium edition*. Ottawa, ON: Aviation Publishers Co. Limited.

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Verify against the official publication.



Note. From "Online Free Private Pilot Ground School", The Aircraft Powerplant. Retrieved November 27, 2008, from http://www.free-online-private-pilot-ground-school.com/aircraft-powerplant.html

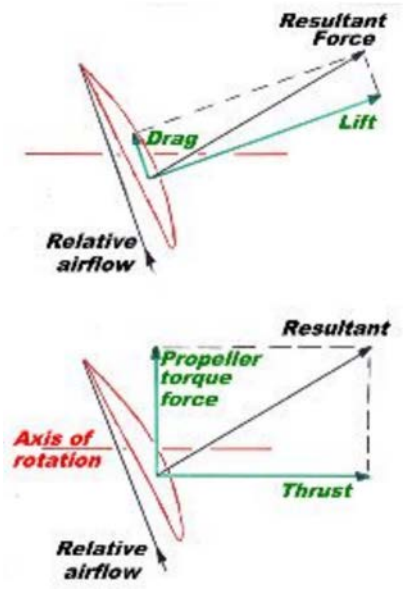
Figure A-1 Propeller Blade Shape



Note. From "Online Free Private Pilot Ground School", The Aircraft Powerplant. Retrieved November 27, 2008, from http://www.free-online-private-pilot-ground-school.com/aircraft-powerplant.html

Figure A-2 Relationship of Travel Distance and Speed of Various Portions of Propeller Blade

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Verify against the official publication.



Note. From "Recreational Aviation Australia Incorporated", Engine and Propeller Performance. Retrieved March 12, 2009, from http://www.auf.asn.au/groundschool/propeller.html

Figure A-3 Forces Acting on a Propeller Blade

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