**ROYAL CANADIAN AIR CADETS**

**PROFICIENCY LEVEL FOUR**

**INSTRUCTIONAL GUIDE**

**SECTION 6**

# EO C432.03 – DESCRIBE GAS TURBINE ENGINES

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 gas turbine engines.

## INTRODUCTION

### REVIEW

Nil.

### OBJECTIVES

By the end of this lesson the cadet shall have described gas turbine engines.

### IMPORTANCE

It is important for cadets to be able to describe gas turbine engines as a solid understanding of gas turbine engines 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 turbojets.**

Time: 10 min Method: Interactive Lecture

**TURBOJETS**

Newton's third law states that for every action there is an equal and opposite reaction. All propulsion systems rely on this fact in some way. A turbojet engine is a reactive engine, which creates thrust by ejecting hot gases to create a force, as described by Newton's third law of motion.

The amount of thrust developed by ejecting hot gases depends on the mass and velocity of the material ejected. A turbojet generates thrust by imparting a relatively large acceleration to a relatively small mass of air.




Show the slide of Figure A-1 to the cadets.

Air is brought into the engine through the intake opening at the front and compressed by a series of compressor blades. Once compressed, fuel is added and the mixture is ignited. The hot gases created by the very rapidly burning fuel / air mixture are highly pressurized. These high pressure gases exit at a high velocity out of the back of the engine. Between the combustion chamber and the exhaust nozzle, the high pressure gases are used to turn a turbine that is connected to the compressor blades.



In a reciprocating engine (eg, radial, in-line, horizontally opposed), a new combustion process occurs during each stroke / cycle.

In a turbojet engine, the combustion process is continuous from the time the engine is started until the engine is shut down.

To start the engine, pressurized air is injected into the engine from either an on-board or ground-based source. Another way is to use an alternate power source to spin the compressor blades, drawing air into the engine. Once a sufficient volume of air is flowing into the combustion chamber, fuel and an ignition source can be added. Once combustion has started and the hot exhaust gases are spinning the turbine connected to the compressor blades, the engine is capable of drawing air into itself on its own, and the on-board or ground-based air / power source can be disconnected.



As an aircraft with a turbojet engine flies faster, more air is pushed into the engine as a result of the forward motion. This improves the fuel efficiency of the engine. A turbojet engine becomes more fuel efficient as the airspeed increases.

Conversely, turbojets become fuel inefficient at low airspeeds.

Turbojets can usually be identified visually by their external shape. Turbojets typically have a constant diameter from the front of the engine (air intake) to the rear of the engine (exhaust nozzle).



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**CONFIRMATION OF TEACHING POINT 1**

**QUESTIONS**:

Q1. Which law of motion does a turbojet engine demonstrate?

Q2. What is different about the combustion in a turbojet engine, when compared to a reciprocating engine?

Q3. What happens to the fuel efficiency of a turbojet engine as the airspeed increases?

**ANTICIPATED ANSWERS**:

A1. A turbojet engine demonstrates Newton's third law of motion.

A2. In a turbojet engine, the combustion process is continuous from the time the engine is started until the engine is shut down.

A3. A turbojet engine becomes more fuel efficient as the airspeed increases.

**Teaching point 2** **Describe turbofans.**

Time: 10 min Method: Interactive Lecture

**TURBOFANS**




Show the slide of Figure A-2 to the cadets.

The turbofan is a turbojet with a fan attached in front of the compressor blades. The fan diameter is larger than the engine core and some of the air moved by the fan bypasses the engine core. This air is moved backwards by the fan in the same way that a propeller works and creates additional thrust for the engine.

In a low-bypass turbofan, the amount of air that bypasses the engine and the amount of air that enters the engine core are approximately equal. In a high-bypass turbo fan, approximately four times as much air may bypass the engine core, which may result in up to 80 percent of the total thrust coming from the bypass portion of the engine.




Show the slide of Figure A-3 to the cadets.



Turbofans are more fuel efficient than turbojets, especially at lower airspeeds. They also produce less noise than turbojets. A turbofan produces more thrust than a turbojet of a similar physical size.

Turbofans can usually be identified visually by their external shape. Turbofans typically have an air intake that is two to four times the diameter of the exhaust nozzle.



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Additional advantages of a turbofan engine include:

- very high power to weight ratio, compared to reciprocating and turbojet engines; and
- less vibration than a reciprocating engine.

Disadvantages of a turbofan engine include:

- high cost, and
- delayed response to changes in power settings.

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**CONFIRMATION OF TEACHING POINT 2**

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**QUESTIONS**:

Q1. What is a turbofan engine?

Q2. How much air may bypass the engine core in a high-bypass turbofan engine?

Q3. What are two advantages of a turbofan engine?

**ANTICIPATED ANSWERS**:

A1. A turbofan is a turbojet with a fan attached in front of the compressor blades.

A2. In a high-bypass turbofan approximately four times as much air that enters the engine core may bypass the engine core.

A3. Two advantages of a turbofan engine include:

- very high power to weight ratio, compared to reciprocating and turbojet engines; and
- less vibration than a reciprocating engine.

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**Teaching point 3** **Describe turboprops and turboshafts.**

Time: 5 min Method: Interactive Lecture

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Instead of using the power of the exhaust gases to produce thrust directly, the gases can be used to turn a turbine connected to a propeller or a shaft.

**TURBOPROPS**




Show the slide of Figure A-4 to the cadets.

When the power of the exhaust gases are used to turn a propeller, the engine is called a turboprop. In a fixed shaft turboprop, the same turbine turns both the compressor blades and the shaft connected to the propeller. In a free turbine turboprop, a separate turbine is used to turn the shaft connected to the propeller.



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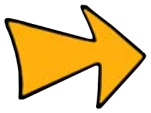

The PT6 turboprop engine, manufactured by Pratt and Whitney Aircraft of Canada, is one of the most popular turboprop engines in the world. It comes in a variety of power outputs and is used in a wide range of aircraft.



In all turboprop engines, the shaft from the turbine is connected to a gearbox to reduce the speed of the shaft to a range that is suitable for spinning the propeller.

**TURBOSHAFTS**

If the shaft of the gas turbine engine is connected to something other than a propeller, the engine is called a turboshaft. The shaft will be connected to a transmission system, and may be used to drive helicopter rotors, electrical generators, compressors, pumps, marine propulsion systems (eg, ships), and / or land propulsion systems (eg, tanks).

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**CONFIRMATION OF TEACHING POINT 3**

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**QUESTIONS**:

Q1. What is the difference between a turboprop and a turboshaft engine?

Q2. What is the shaft connected to in a turboprop engine to reduce the speed of the shaft?

Q3. For what can a turboshaft engine be used?

**ANTICIPATED ANSWERS**:

A1. In a turboprop engine, the shaft is connected to a propeller; in a turboshaft engine, it is connected to something other than a propeller.

A2. In a turboprop engine, the shaft from the turbine is connected to a gearbox to reduce the speed of the shaft to a range that is suitable for spinning the propeller.

A3. A turboshaft engine may be used for:

- helicopter rotors,
- electrical generators,
- compressors,
- pumps,
- marine propulsion systems (eg, ships), and / or
- land propulsion systems (eg, tanks).

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**END OF LESSON CONFIRMATION**

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**QUESTIONS**:

Q1. How does a turbojet generate thrust?

Q2. How can a turbofan be visually identified?

Q3. How is a free turbine turboprop different from a fixed shaft turboprop?



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**ANTICIPATED ANSWERS**:

A1. A turbojet generates thrust by imparting a relatively large acceleration to a relatively small mass of air.

A2. Turbofans typically have an air intake that is two to four times the diameter of the exhaust nozzle.

A3. In a free turbine turboprop, a separate turbine is used to turn the shaft connected to the propeller. In a fixed shaft turboprop, the same turbine turns both the compressor blades and the shaft connected to the propeller.

## CONCLUSION

### HOMEWORK / READING / PRACTICE

Nil.

### METHOD OF EVALUATION

Nil.

### CLOSING STATEMENT

Being able to describe gas turbine engines is important for understanding more complex material. A solid understanding of gas turbine engines is required to pursue future aviation training and provides knowledge for potential instructional duties.

### 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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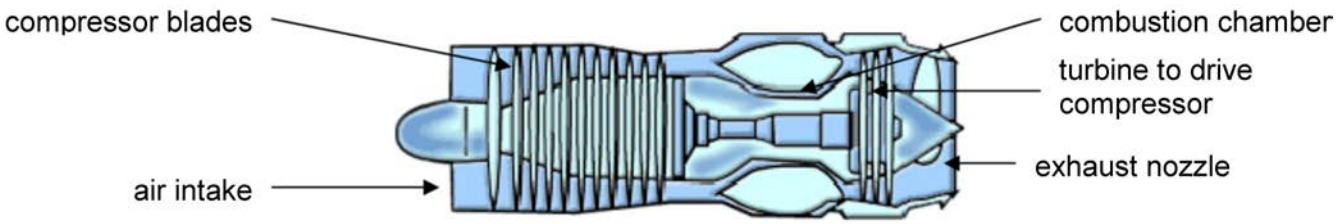
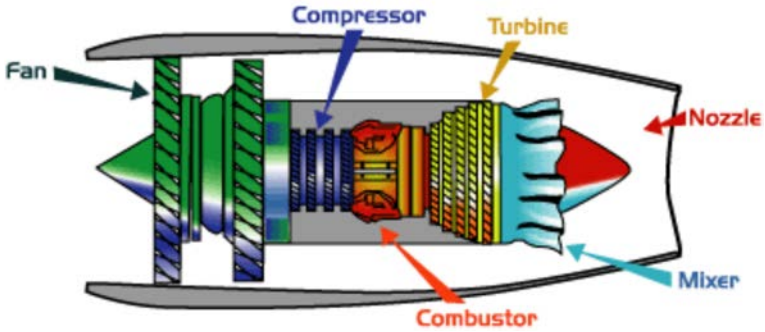


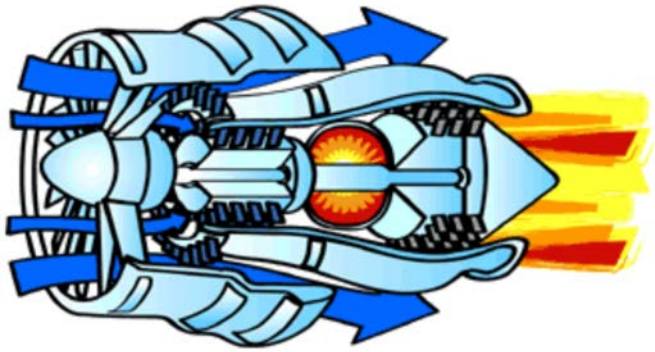

*Note. From "Engines", NASA Ultra Efficient Engine Technology. Retrieved March 19, 2009, from http://www.ueet.nasa.gov/StudentSite/engines.html*

Figure A-1 Turbojet Engine




*Note. From "Engines", NASA Ultra Efficient Engine Technology. Retrieved March 19, 2009, from http://www.ueet.nasa.gov/StudentSite/engines.html*

Figure A-2 Turbofan Engine



*Note. From "Engines", NASA Ultra Efficient Engine Technology. Retrieved March 19, 2009, from http://www.ueet.nasa.gov/StudentSite/engines.html*

Figure A-3 Airflow Through a Turbofan Engine



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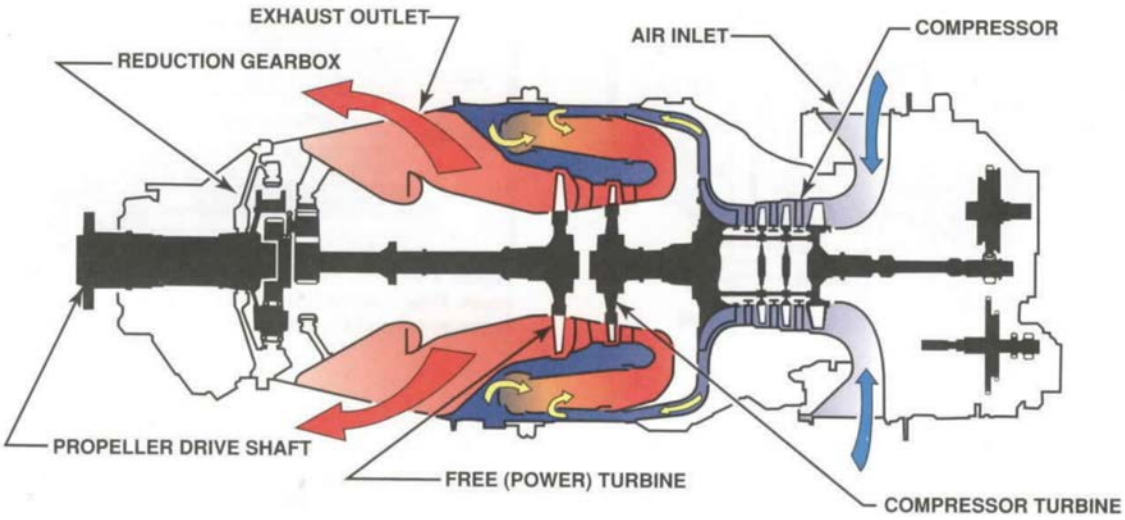


*Note. From A&P Technician Powerplant (p. 3-6), by Jeppesen Standard Training Products, 2000, Englewood, CO:Jeppesen Sanderson Training Systems.*

Figure A-4 Free Turbine Turboprop Engine



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