ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL FOUR

INSTRUCTIONAL GUIDE

SECTION 1

EO M432.01 – DESCRIBE FUEL 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.

Photocopy the handout located at Attachment B for each cadet.

PRE-LESSON ASSIGNMENT

Nil.

APPROACH

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

INTRODUCTION

REVIEW

Nil.

OBJECTIVES

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

IMPORTANCE

It is important for cadets to be able to describe fuel systems as a solid understanding of fuel 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 fuel systems.**

Time: 10 min Method: Interactive Lecture

THE FUEL SYSTEM

An aircraft fuel system stores and delivers the proper amount of fuel for all phases of flight, including:

- normal flight,
- violent manoeuvres,
- sudden acceleration, and
- sudden deceleration.

Fuel systems include the following parts:

- fuel tanks,
- a fuel selector valve,
- fuel lines and filters,
- a fuel quantity gauge, and
- fuel primer.

Pressure-Feed System



Show slide of Figure A-1 to the cadets.

Aircraft with low-wing configurations and large aircraft with a large volume of fuel movement use an engine-driven fuel pump to provide the pressure to keep fuel flowing. This system includes:

- the basic pump,
- auxiliary electric pumps for emergency situations,
- a booster pump to create the pressure required to start the fuel flowing before the engine is running, and
- the pressure gauge mounted on the cockpit panel used to read the pressure of fuel entering the carburetor.

Gravity-Feed System



Show slide of Figure A-2 to the cadets.

High-wing, low-powered light aircraft use the gravity-feed system. The bottom of the fuel tank in the wing must be high enough to provide pressure for the fuel to travel past the fuel selector to the carburetor.

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Fuel Selector Valve

The fuel selector valve is used by the pilot to select the desired fuel tank to draw fuel. The selector valve may also be used to shut off the flow of fuel from the tanks.

A fuel selector valve can be operated manually or electrically depending of the installation.

FUEL

Aviation fuel has been specially formulated for use in aircraft. It is available in several different types / grades. The approved fuel types are specified in the pilot operating handbook.

Fuel Types

Fuel used in modern high compression engines must burn slowly and expand evenly rather than explode quickly (detonation). High octane fuels meet this requirement. The octane rating of fuels is calculated by the ratio of octane and heptane.

Octane. A substance which possesses minimum detonating qualities.

Heptane. A substance which possesses maximum detonating qualities.



Show slide of Figure A-3 to the cadets.

Proportion of octane to heptane is expressed as a percentage. For example 73 octane means 73 percent octane and 27 percent heptane.

Higher octane fuels are treated with sulphuric acid, lye, etc, used to remove the gum, acid, and other impurities.

Octane numbers can only go as high as 100. Beyond this, the performance number is the anti-knock value of the fuel for octane numbers above 100. Fuel grades are expressed by two performance numbers the first number indicates octane rating at lean mixture conditions, and the second number indicates octane rating at rich mixture condition.

Grade 100 / 130 indicates:

- lean mixture performance number of 100, and
- rich mixture performance number of 130.

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CONFIRMATION OF TEACHING POINT 1

QUESTIONS:

Q1. What fuel-feed system does an aircraft with low-wing configuration use?

Q2. For what is the fuel selector valve used?

Q3. How are octane ratings of fuels calculated?

ANTICIPATED ANSWERS:

A1. An aircraft with low-wing configuration uses a pressure-feed system.

A2. The fuel selector valve is used by the pilot to select the desired fuel tank to draw fuel. The selector valve may also be used to shut off the flow of fuel from the tanks.

A3. Octane ratings of fuels are calculated as a ratio of octane and heptane.

Teaching point 2 **Describe carburetors.**

Time: 10 min Method: Interactive Lecture

CARBURETORS



Show slide of Figure A-4 to the cadets.

The heat energy in an internal combustion engine is developed from the burning of a mixture of gasoline and air. The carburetor measures the correct quantity of gasoline, vaporizes fuel, mixes it with the air in the required proportion and delivers the mixture to the cylinder when the combustion occurs.

An engine will run hotter with a lean mixture than a rich mixture as the lean mixture will burn slower and the cylinder walls are exposed to high heat for a longer time. A rich mixture burns quickly exposing the cylinder walls to high temperatures for a shorter time and the additional fuel in the fuel / air mix cools the engine.

The carburetor involves numerous complex devices to control the mixture ratio. Two types of carburetors used, include float carburetor, or pressure carburetor.

Float Carburetor



Show slide of Figure A-5 to the cadets.

Fuel flows through the fuel lines, enters the carburetor at the float valve and into the float chamber. A needle attached to the float, resting on the fuel within the chamber, opens and closes an opening at the bottom of the carburetor bowl. The float chamber is vented so the atmospheric and chamber pressure equalizes as the aircraft climbs and descends.

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Air flows through an air filter usually located at an air intake in the front part of the engine cowling. The filtered air flows into the carburetor through a venturi (narrow throat in the carburetor). The air speed increases, creating a low pressure area which draws fuel at atmospheric pressure.

The air and vaporized fuel is regulated, in volume, by the throttle valve, enters the intake manifold and is distributed to the individual cylinders. The pilot is able to control the amount of fuel / air mixture from within the cockpit using the throttle control.



Forward movement of the throttle opens the throttle valve, which increases the fuel / air mixture, and increases the power being produced by the engine.

Aft movement of the throttle closes the throttle valve, which reduces the volume of fuel / air mixture, and decreases the power being produced by the engine.

Mixture Control



The correct fuel / air mixture will be obtained at sea level as carburetors are normally calibrated for sea level operation.

As altitude increases, the density of the air decreases and a given volume of air weighs less. The proportion of air by weight to that of fuel will become less although the volume remains the same. The mixture at higher altitude becomes over-rich causing fuel waste and loss of power.

A mixture control is fitted to the carburetor that adjusts the amount of fuel being drawn from the nozzle, restoring the proper fuel / air mix.

The general rules when using a manual mixture control are:

- rich mixtures—high power settings, and
- leaner mixtures—cruise power settings.

Carburetor Icing



Show slide of Figure A-6 to the cadets.

Distribute the handout located at Attachment B to each cadet.

With temperatures ranging from minus 5 degrees Celsius to plus 30 degrees Celsius and under certain moist atmospheric conditions, ice can form in the induction system closing off the flow of fuel to the engine. Ice can form on various surfaces of the carburetor especially on the throttle.



Show slide of Figure A-7 to the cadets.

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Modern aircraft have incorporated a method of directing heated air into the carburetor air intake, activated by the carburetor hot air handle in the cockpit. This heated air can prevent ice from forming or melt ice that has already formed.

CONFIRMATION OF TEACHING POINT 2

QUESTIONS:

Q1. How are the fuel / air proportions calculated?

Q2. What does the mixture control adjust?

Q3. What do modern aircraft have to melt ice that has formed?

ANTICIPATED ANSWERS:

A1. Fuel / air proportions are calculated by weight not volume.

A2. The mixture control adjusts the amount of fuel being drawn from the nozzle, restoring the proper fuel / air mix.

A3. Modern aircraft have incorporated a method of directing heated air into the carburetor air intake, activated by the carburetor hot air handle in the cockpit.

Teaching point 3 **Describe fuel injection.**

Time: 5 min Method: Interactive Lecture

FUEL INJECTION

With a fuel injection system, a control valve supplies pressurized fuel continuously to the induction system near the intake valve. The fuel is vaporized and sucked into the cylinder during the intake stroke.

Advantages of fuel injection include:

- more uniform distribution of fuel to all cylinders,
- better cooling, through the elimination of lean hot mixtures to some of the more distant cylinders,
- fuel saving through uniform distribution,
- increased power since the heat carburetor air is eliminated, and
- elimination of the hazard of carburetor icing.



Throttle ice can occur when the temperature is less than 5 degrees Celsius.

Impact ice can gather in bends in the system, impact tubes, and air filter.

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CONFIRMATION OF TEACHING POINT 3

QUESTIONS:

Q1. What does the control valve do?

Q2. What are the advantages of fuel injection?

Q3. Where can impact ice gather?

ANTICIPATED ANSWERS:

A1. The control valve supplies pressurized fuel continuously to the induction system near the intake valve.

A2. Advantages of fuel injection include:

- more uniform distribution of fuel to all cylinders,
- better cooling, through the elimination of lean hot mixtures to some of the more distant cylinders,
- fuel saving through uniform distribution,
- increased power since the heat carburetor air is eliminated, and
- elimination of the hazard of carburetor icing

A3. Impact ice can gather in the system, impact tubes, and air filter.

END OF LESSON CONFIRMATION

QUESTIONS:

Q1. What fuel-feed system does a high-wing, low-powered light aircraft use?

Q2. Why is leaning the engine both practical and economical?

Q3. When can throttle ice occur?

ANTICIPATED ANSWERS:

A1. A high-wing, low-powered light aircraft uses a gravity-feed system.

A2. It results in:

- better fuel economy lowering the cost of operation,
- a smoother running engine,
- a more efficient engine giving higher indicated airspeeds and better aircraft performance,
- extended range of the aircraft at cruise,
- less spark plug fouling and longer life for spark plugs,
- more desirable engine temperatures, and
- cleaner combustion chambers and less chance of pre-ignition from undesirable deposits.

A3. Throttle ice can occur when the temperature is less than 5 degrees Celsius.

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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 fuel systems is important for understanding more complex material. A solid understanding of aero engines is required to pursue future aviation training.

INSTRUCTOR NOTES / REMARKS

Cadets who are qualified Advanced Aviation may assist with this instruction.

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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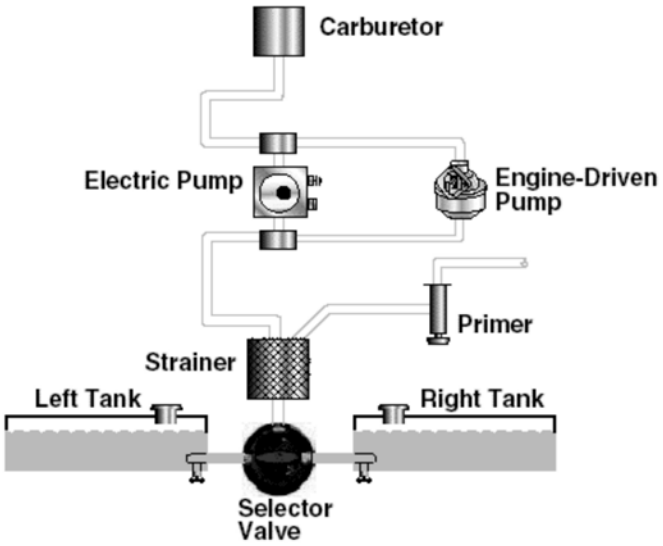
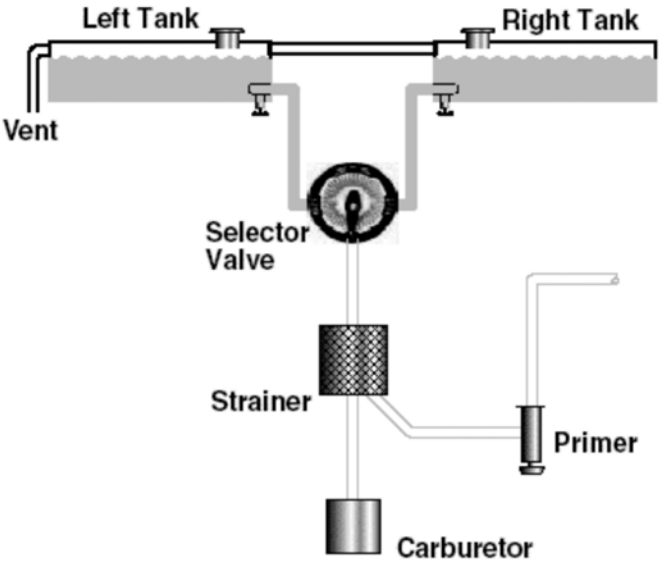


Note. From "Online Free Private Pilot Ground School", The Aircraft Powerplant. Retrieved November 24, 2008, from http://www.free-online-private-pilot-ground-school.com/aircraft-powerplant.html

Figure A-1 Pressure-Feed System



Note. From "Online Free Private Pilot Ground School", The Aircraft Powerplant. Retrieved November 24, 2008, from http://www.free-online-private-pilot-ground-school.com/aircraft-powerplant.html

Figure A-2 Gravity-Feed System

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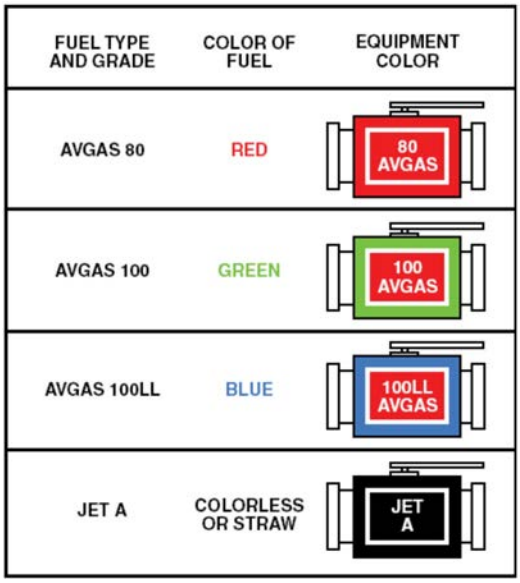
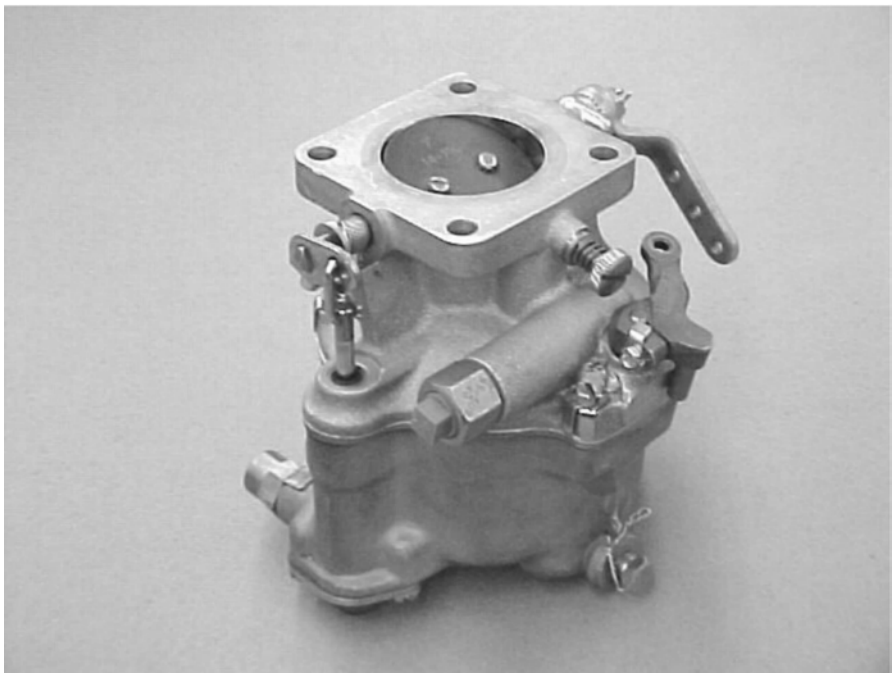


Note. From "Online Free Private Pilot Ground School", The Aircraft Powerplant. Retrieved November 24, 2008, from http://www.free-online-private-pilot-ground-school.com/aircraft-powerplant.html

Figure A-3 Fuel Types



Note. From "Online Free Private Pilot Ground School", The Aircraft Powerplant. Retrieved November 24, 2008, from http://www.free-online-private-pilot-ground-school.com/aircraft-powerplant.html

Figure A-4 Carburetor

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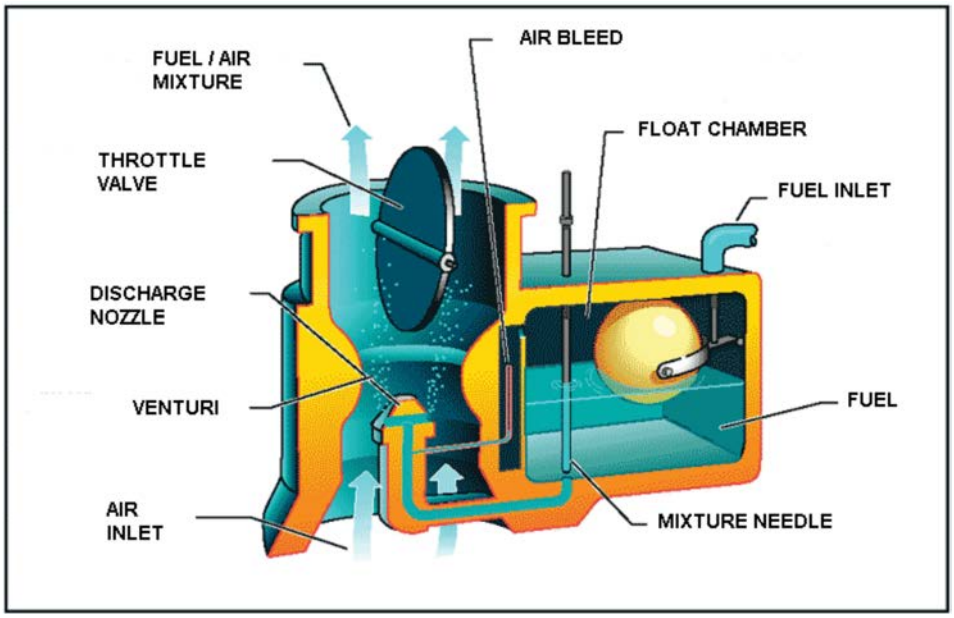
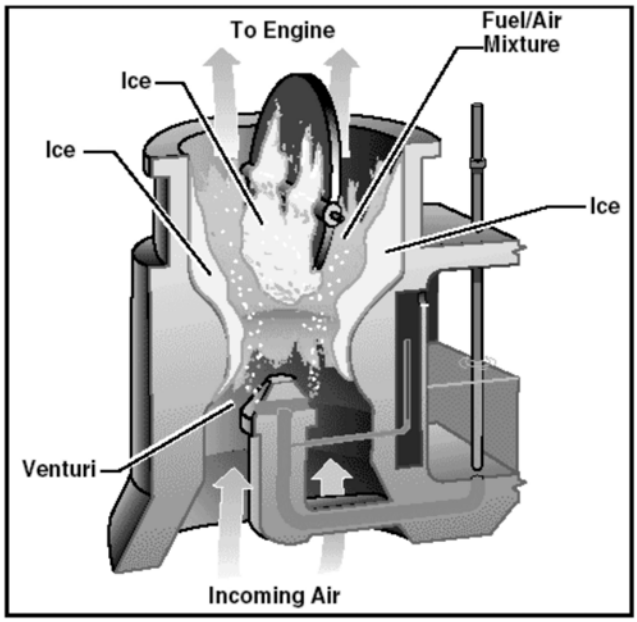


Note. From "Online Free Private Pilot Ground School", The Aircraft Powerplant. Retrieved November 26, 2008, from http://www.free-online-private-pilot-ground-school.com/aircraft-powerplant.html

Figure A-5 Float-Type Carburetor



Note. From "Online Free Private Pilot Ground School", The Aircraft Powerplant. Retrieved November 26, 2008, from http://www.free-online-private-pilot-ground-school.com/aircraft-powerplant.html

Figure A-6 Carburetor Icing

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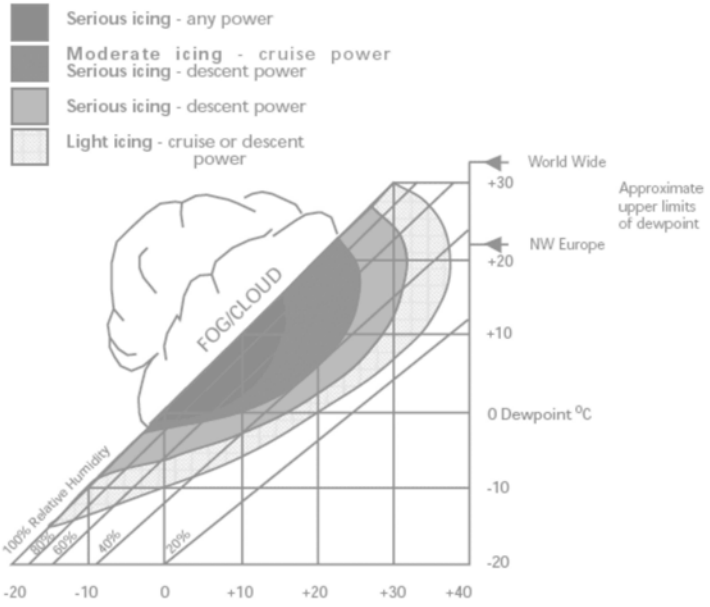

Note. From "VAF Vansairforce.net", The Truth about Carb Icing, by J. Oldenkamp, 2006, Soonabe, Fl. Retrieved November 27, 2008, from http://www.vansairforce.com/community/showthread.php?t=9499

Figure A-7 Carburetor Icing Chart

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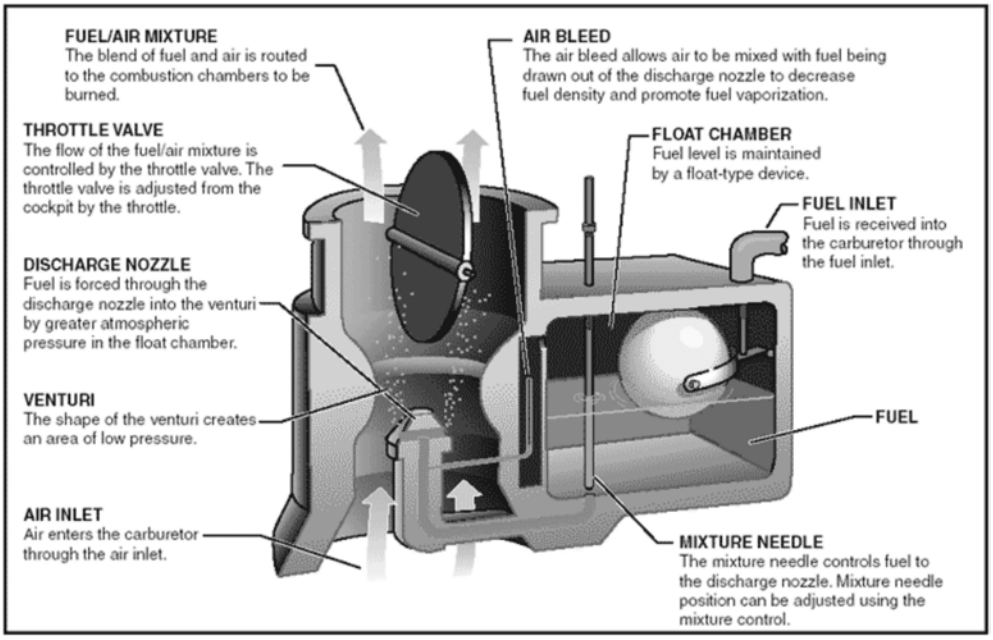
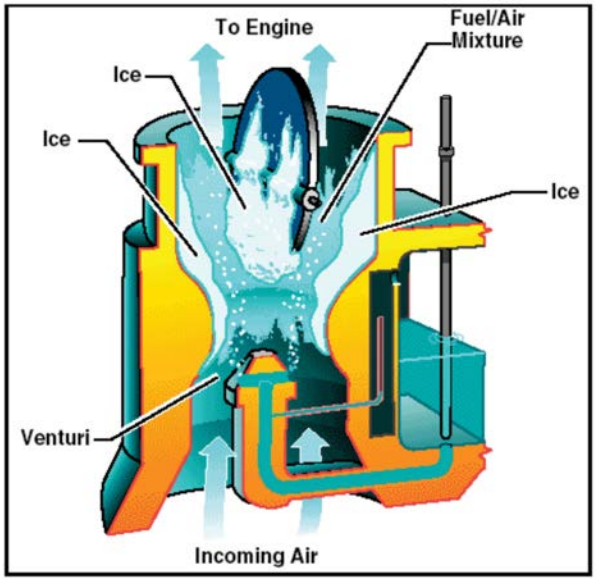
CARBURETOR STUDY HANDOUT



Note. From "Online Free Private Pilot Ground School", The Aircraft Powerplant. Retrieved November 26, 2008, from http://www.free-online-private-pilot-ground-school.com/aircraft-powerplant.html

Figure B-1 Float-type Carburetor



Note. From "Online Free Private Pilot Ground School", The Aircraft Powerplant. Retrieved November 26, 2008, from http://www.free-online-private-pilot-ground-school.com/aircraft-powerplant.html

Figure B-2 Carburetor Icing

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