

Unit C: Agricultural Power Systems

Lesson 1: Understanding Principles of Operation of Internal Combustion Engines

Student Learning Objectives:

Instruction in this lesson should result in students achieving the following objectives:

1. Define internal combustion engine and explain its principal parts.
2. Describe four events of the internal combustion engine.
3. Explain the differences in operation of four-stroke and two-stroke internal combustion engines.
4. Classify internal combustion engines.

Recommended Teaching Time: 2 hours

Recommended Resources: The following resources may be useful in teaching this lesson:

- Johnson, Donald M., et al. *Mechanical Technology in Agriculture*. Danville, Illinois: Interstate Publishers, Inc., 1998. (Textbook, Chapter 8)
- Phipps, Lloyd J., and Carl L. Reynolds. *Mechanics in Agriculture*. Danville, Illinois: Interstate Publishers, Inc., 1992. (Textbook, Chapter 21)
- Herren, Ray V., and Elmer L Cooper. *Agricultural Mechanics Fundamentals & Applications*. Albany, New York: Delmar Publishers, Inc., 2002. (Textbook, Chapter 29)
- Phipps, Lloyd J., et al. *Introduction to Agricultural Mechanics*, Second Edition. Upper Saddle River, New Jersey: Prentice Hall Interstate, 2004. (Textbook and Activity Manual, Chapter 18))

List of Equipment, Tools, Supplies, and Facilities:

- Writing surface
- PowerPoint Projector
- PowerPoint Slides
- Transparency Masters
- Copies of student worksheets
- Small gasoline engine parts

Terms: The following terms are presented in this lesson (shown in bold italics and on PowerPoint Slides 2 and 3):

- Compression
- Compression stroke
- Connecting rod
- Crankshaft
- Cycle
- Cylinder
- Diesel engines
- Engine block
- Engine displacement
- Exhaust
- Exhaust stroke
- Flat
- Four-stroke engine
- Gasoline engines
- In-line
- Intake

- Intake stroke
- Internal combustion engine
- Large engines
- Multi-cylinder
- Piston
- Power
- Power stroke
- Reed valves
- Single-cylinder
- Small engines
- Two-stroke engine
- Vee-block
- Wrist pin

Interest Approach:

Display pictures of different types of agricultural machines. Ask the students if they can identify the different types of internal combustion engines used to power the machines.

SUMMARY OF CONTENT AND TEACHING STRATEGIES

Objective 1: Define internal combustion engine and explain its principal parts.

Anticipated Problem: What is an internal combustion engine? What are its principal parts?

(PowerPoint Slide 4)

- I. Much of the advancements in agriculture are due to increased efficiency. This increased efficiency has meant each producer can accomplish more work. A large portion of this increase in productivity is due to the internal combustion engine. An **internal combustion engine** is a device that converts energy contained in fuel into rotating power. Common fuels are made from petroleum or manufactured from grain products. Internal combustion engines are made up of various parts housed within an engine block. The **engine block** consists of a large metal structure that houses the following four parts:

(PowerPoint Slides 5, 6, 7, 8, and 9)

- A. The **cylinder** is the part of the engine block where the combustion takes place. The number of cylinders within an engine will vary from one to eight.
- B. The **piston** is a plunger which works inside the cylinder. Each piston contains rings, which fit tightly against the inside cylinder walls and prevent air from leaking past the piston.
- C. The **connecting rod** connects the piston to the crankshaft. The rod is fastened to the piston by a **wrist pin**.
- D. The **crankshaft** is a shaft with offsets to which the connecting rods are attached. The name results from the offsets having the appearance of hand crank. Force created by the connecting rod on the offsets causes the crankshaft to turn producing a rotary motion.

Use TM: 1-1, TM: 1-2, and TM: 1-3 to illustrate the primary parts of an internal combustion engine. A more effective strategy may be to have students identify the primary parts on an actual engine in your shop.

Objective 2: Describe the four events of the internal combustion engine.

Anticipated Problem: What are the four events that take place in internal combustion engines?

(PowerPoint Slides 10 and 11)

II. Internal combustion engines are mechanical devices that transform certain fuels into work. The fuel, which is in a gaseous form when it enters the cylinders of an engine, is changed into an explosive mixture when united with the correct proportions of air. This explosive mixture is compressed and ignited in a cylinder, and the explosion forces the piston downward. The internal combustion engine operates based upon the principle of a cycle. A **cycle** is a series of events that are repeated over and over again. When these events occur within an internal combustion engine, they are referred to as strokes. The four strokes that make up a cycle within an operating internal combustion engine are:

(PowerPoint Slide 12)

A. **Intake** is the process of getting the fuel and air required for combustion to take place in the chamber. During the intake stroke, the exhaust valve remains closed and the intake valve is open. As the piston moves downward, a mixture of fuel and air is drawn into the cylinder.

(PowerPoint Slide 13)

B. **Compression** is the process of compressing the fuel-air mixture in the combustion chamber to increase the potential chemical energy of the heat from combustion. During the compression stroke, the intake and exhaust valves are closed. The piston moves toward the valves and compresses the fuel-air mixture. This turns the crankshaft which pushes the connector rod and moves the piston.

(PowerPoint Slide 14)

C. **Power** is the result of converting the chemical potential energy to mechanical power by the rapid expansion of heated gases. The gases are produced by the combustion of the compressed fuel-air mixture in the combustion chamber.

(PowerPoint Slide 15)

D. **Exhaust** is the process of removing the spent products resulting from combustion in the combustion chamber. After the power stroke, the cylinder contains burned gases. During the exhaust stroke, the exhaust valve opens and the spent gases are forced from the cylinder.

Use TM: 1-4 (PowerPoint Slide 11) to illustrate the four strokes of an internal combustion engine. Discussing these processes using an actual engine would be most effective.

Objective 3: Explain the differences in operation of four-stroke and two-stroke internal combustion engines.

Anticipated Problem: How do four-stroke and two-stroke engines operate differently?

III. A cycle is a series of events starting at a given point, going through procedures, and returning to the starting point. Both two-stroke cycle and four-stroke cycle internal combustion engines are widely used in agricultural application. In order to use them most efficiently, it is important to understand the differences in how they operate.

(PowerPoint Slide 16)

A. A **four-stroke engine** has a series of four events or strokes that must be completed within the cycle. Generally, the four-stroke engine operates more quietly, is heavier, has a longer life, and is cleaner burning than a two-stroke engine. The four events that must be completed within the cycle are:

(PowerPoint Slide 17)

1. On the **intake stroke**, the exhaust valve remains closed and the intake valve opens allowing a fuel-air mixture to enter the cylinder.
2. The **compression stroke** occurs when the piston moves back towards the head or top of the cylinder.
3. Ignited by the spark plug, the explosion of a fuel-air mixture drives the piston down during the **power stroke**. Both valves are closed during this stroke.
4. The **exhaust stroke** occurs as the piston returns to the top and the burned gases are released through the exhaust valve.

(PowerPoint Slides 18, 19, and 20)

B. A **two-stroke engine** completes the same series of four events in two strokes. Generally, two-stroke engines are lighter, can be operated in a wider range of positions, have fewer moving parts, and are more applicable to smaller jobs. The crankcase is airtight and does not contain lubricating oil. The oil in a two-stroke cycle engine is blended with the gasoline fuel. Events occur within a two-stroke engine as follows:

1. During the first stroke, the piston moves downward from top dead center (TDC) to bottom dead center (BDC). It is the release of the exhaust gases that drives the piston downward.
2. The second stroke occurs as the piston is moved upward from BDC to TDC. AS the piston moves up, it closes the intake and exhaust ports. This allows the piston to compress the air-fuel mixture for combustion. **Reed valves** are one-way directional valves that allow the air-fuel mixture to enter the crankcase.

Use TM: 1-5 to illustrate the operation of a two-stroke engine. Display TM: 1-6 to summarize the characteristics of each type of engine. If a two-stroke and four-stroke engine is available, examine the parts and the processes that occur.

Objective 4: Classify internal combustion engines.

Anticipated Problem: How can internal combustion engines be classified?

(PowerPoint Slides 21 and 22)

- IV. There are many ways by which internal combustion engines are classified. Classification may be based on piston strokes, engine power, number of cylinders, engine displacement, cylinder arrangement, and/or fuel ignition and combustion.

(PowerPoint Slide 23)

- A. Internal combustion engines are classified as either “two-stroke” or “four-stroke.”

(PowerPoint Slide 24)

- B. Internal combustion engines can be classified by the amount of power they produce. Those engines producing less than 25 horsepower are considered to be **small engines**. Internal combustion engines producing more than 25 horsepower are **large engines**.

(PowerPoint Slide 25)

- C. Engines may be classified by the number of cylinders:
1. **Single-cylinder** engines have only one cylinder.
 2. **Multi-cylinder** engines have 2, 3, 4, 5, 6, 8, or more cylinders.

(PowerPoint Slide 26)

- D. The **engine displacement** describes the total swept volume of the engine cylinders as the pistons complete one stroke. Engine displacement is expressed as either cubic inches (cu. in.) or cubic centimeters (cc).

(PowerPoint Slide 27)

- E. The manner in which the cylinders are arranged is another way to classify engines. Some of the more common arrangements are as follows:
1. **In-line** means all of the cylinders are in a straight line.
 2. The **Vee-block** engines means the cylinders are arranged in a “V” configuration with two banks of cylinders on a 90-degree angle operating off the same crankshaft.
- F. **Flat** refers to cylinder arrangements that are perpendicular, or flat, in the relation to the earth.

(PowerPoint Slide 28)

- G. Engines may be classified by the fuel they burn:
1. Gasoline engines are fuel-powered by a spark ignition.
 2. Diesel engines use glow plugs and fuel in compression ignition.

Use classroom discussion to reinforce the ways internal combustion engines can be classified. Identify traits of each engine type and have students respond aloud as to which engine you are describing.

Review/Summary: The review and summary of the lesson may be accomplished by viewing the transparency masters with the students. **(PowerPoint Slide 29)** A discussion should be performed with students before proceeding with the laboratory activities and testing.

Application: Include one or more of the following student activities using the attached lab sheets.

Engine Identification and Classification LS: 1-1

Evaluation: Objectives should be reviewed by the students. Laboratory activities should be performed before the written test is given to students.

Answers to Sample Test:

Matching

1. I
2. B
3. G
4. H
5. D
6. J
7. E
8. F
9. C
10. A

Fill-in-the-blank

1. Cycle
2. Engine displacement
3. Cylinder
4. Small engines
5. Reed valves

Short Answer

1. Intake stroke, compression stroke, power stroke, exhaust stroke
2. First stroke, second stroke

Understanding Principles of Operation of Internal Combustion Engines

Name: _____

Matching: Match each word with the correct definition.

- | | | |
|-------------------|--------------------|-------------------|
| a. compression | e. exhaust | h. multi-cylinder |
| b. connecting rod | f. gasoline engine | i. piston |
| c. crankshaft | g. four-stroke | j. two-stroke |
| d. diesel engine | | |

- _____ 1. Works as a plunger inside the cylinder.
- _____ 2. Connects the piston to the crankshaft.
- _____ 3. Type of engine which has a series of four events.
- _____ 4. Engines having 2 or more cylinders.
- _____ 5. Engines fuel powered by glow plugs.
- _____ 6. Type of engine which completes all events in two piston strokes.
- _____ 7. The process of removing the spent products of combustion from the combustion chamber.
- _____ 8. Engines fuel powered by a spark ignition.
- _____ 9. Is a central crank-shaped shaft which all connecting rods are fastened.
- _____ 10. Process of compressing the fuel and air mixture in the combustion chamber.

Fill-in-the-blank: Complete the following statements.

- A _____ is considered to be series of events that occur regularly.
- The _____ describes the total swept volume of the engine cylinders as the pistons complete one stroke.
- The _____ is the part of the engine block where combustion takes place.
- Those engines producing less than 25 horsepower are considered to be _____.
- _____ are one-way directional valves that allow the air-fuel mixture to enter the crankcase.

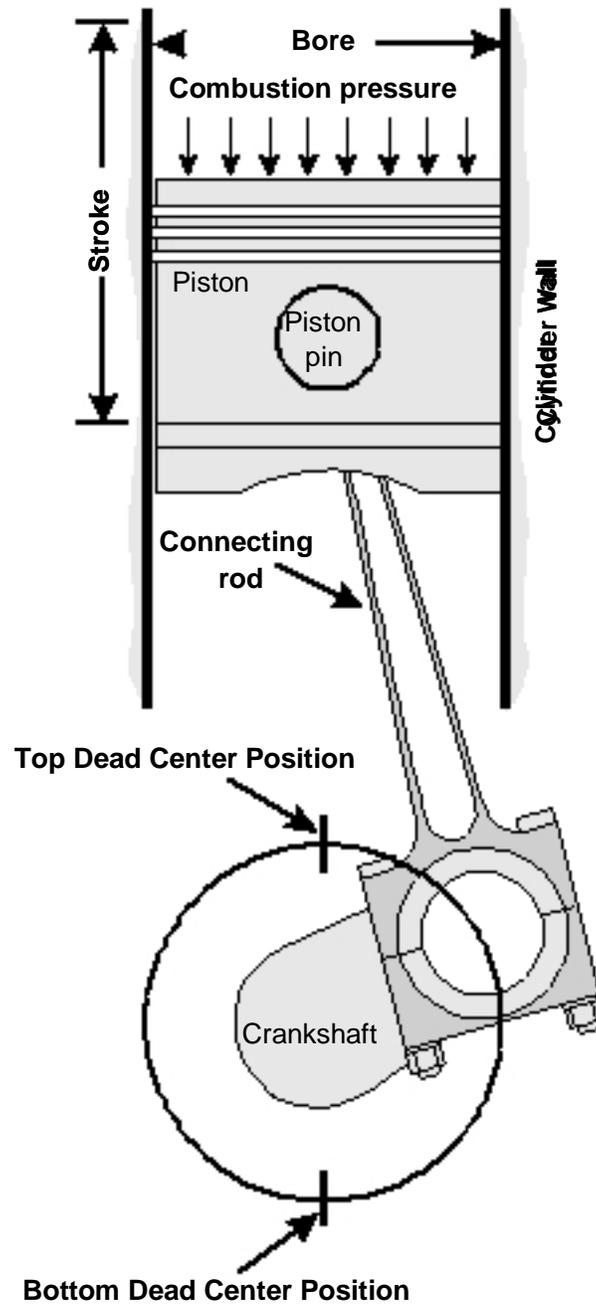
Short Answer: Answer the following question.

1. Explain the four-stroke cycle process.

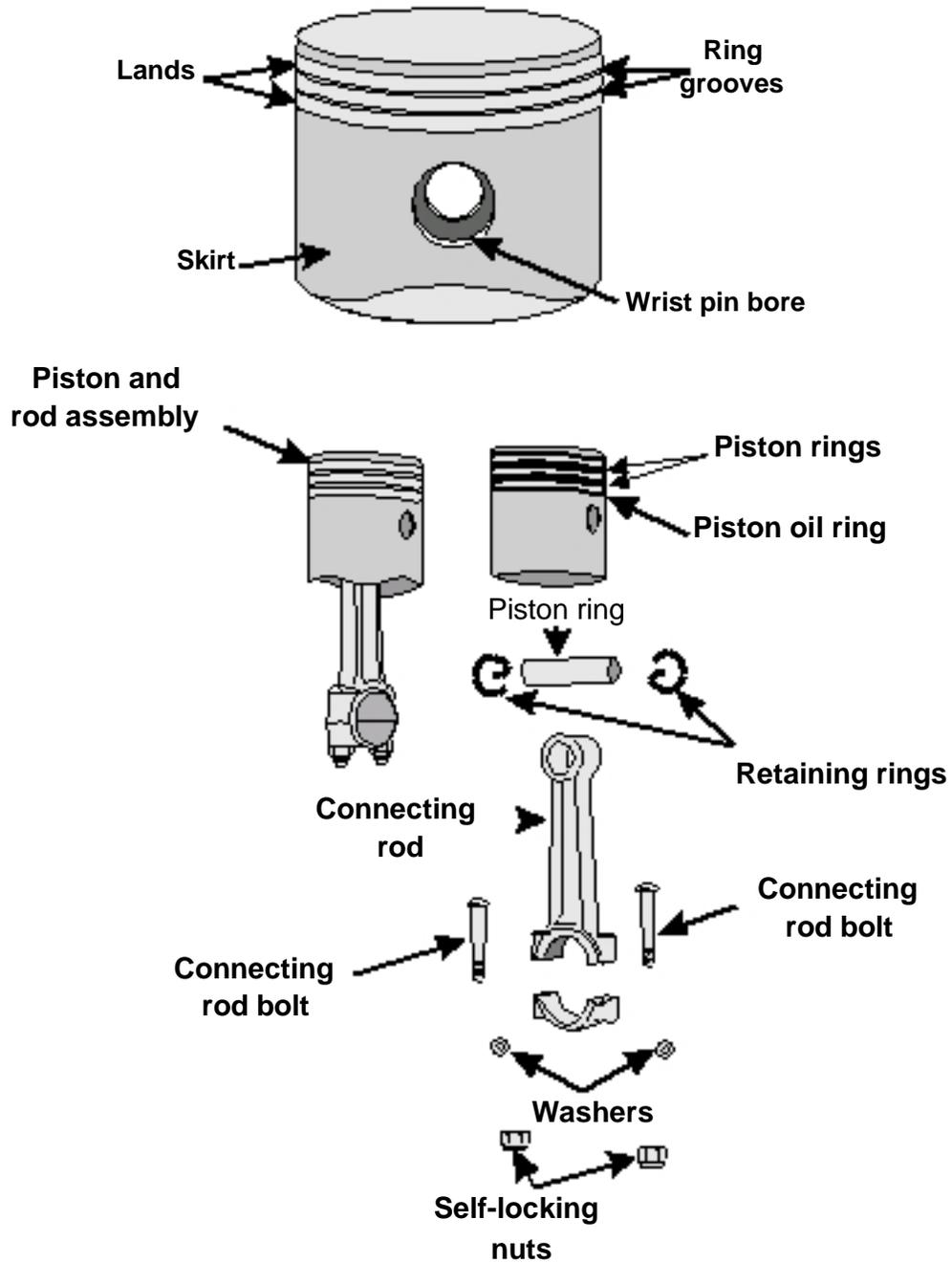
2. Explain the two-stroke cycle process.

TM: 1-1

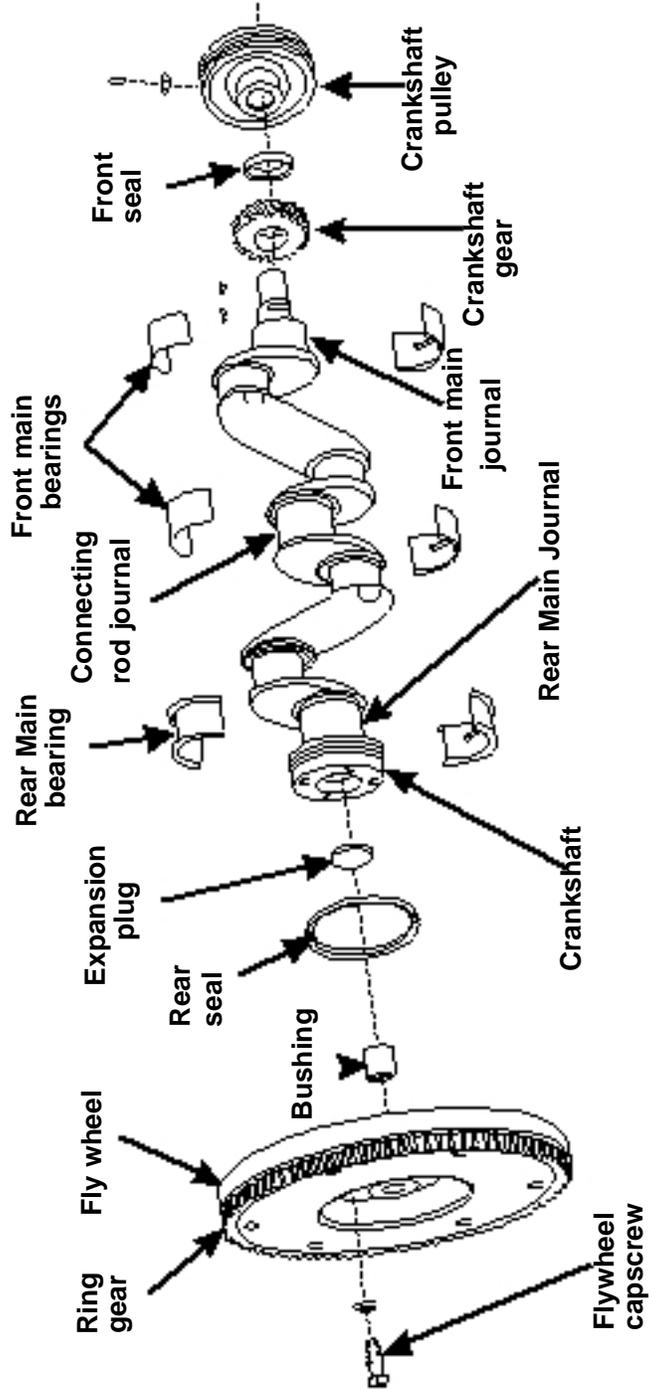
BORE AND STROKE OF A CYLINDER



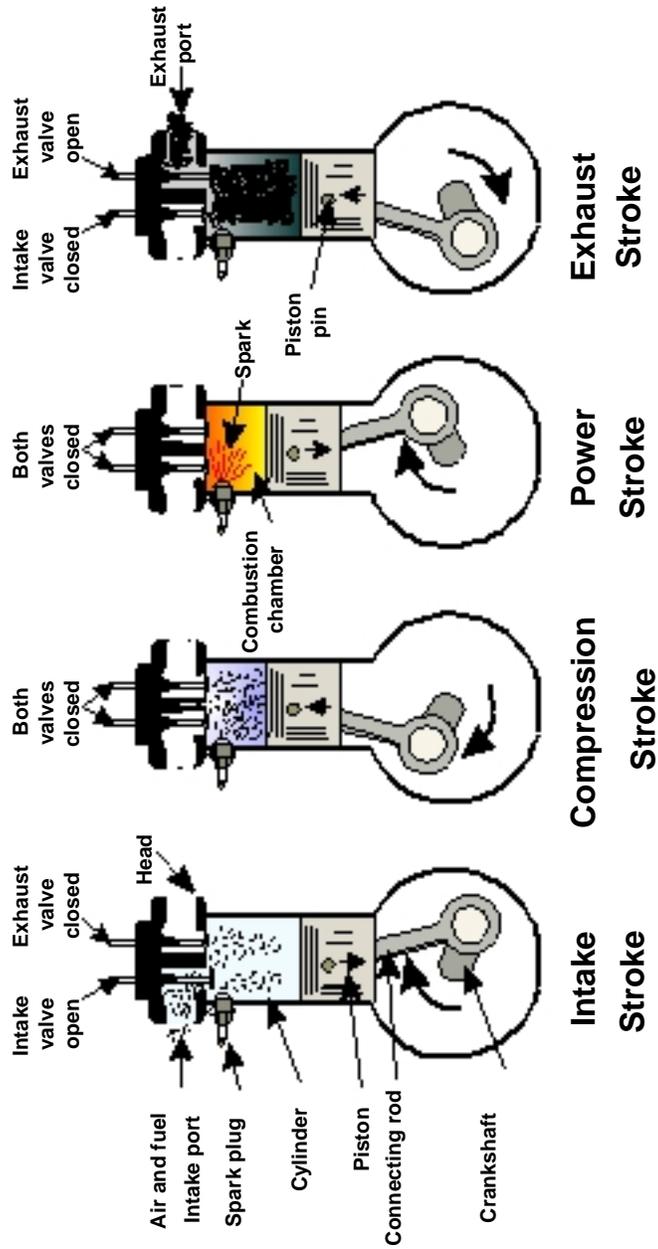
PISTON AND CONNECTING ROD



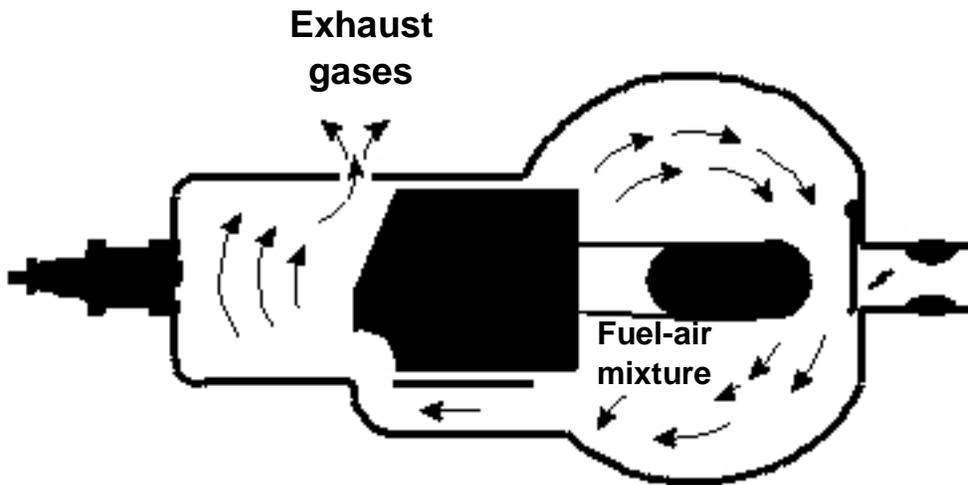
CRANKSHAFT ASSEMBLY



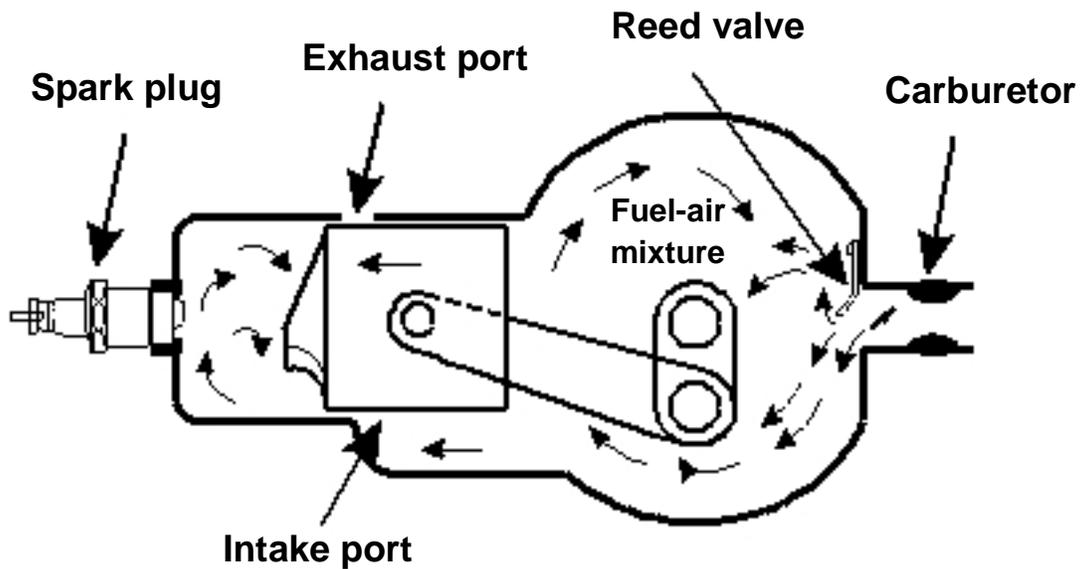
FOUR-STROKE CYCLE ENGINE



TWO-STROKE CYCLE ENGINE



First Stroke



Second Stroke

CHARACTERISTICS OF TWO- AND FOUR-STROKE ENGINES

Two-Stroke Cycle Engines	Four-Stroke Cycle Engines
Lighter weight	Heavier weight
Operates in many positions	Operates in limited positions
Higher power to weight ratio	Lower power to weight ratio
Engine oil usually mixed with fuel	Engine oil in a reservoir
Louder operation	Quieter operation
Higher engine speeds	Slower engine speeds
More vibration	Smoother operation
Rough idling operation	Smoother idling operation

LS: 1-1

ENGINE IDENTIFICATION AND CLASSIFICATION

Instructions: Use the Internet or printed material to gather information for internal combustion engines. For each classification, list at least one manufacturer and the engine's horsepower.

Single-cylinder engines—

Multi-cylinder engines—

In-line engines—

Vee-block engines—

Flat engines—

Gasoline engines—

Diesel engines—