Unit C: Agricultural Power Systems

Lesson 2: Identifying Engine Systems and Their Components

Student Learning Objectives:

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

1. Identify the three broad categories of internal combustion engine systems.
2. Identify the components of the primary or compression system.
3. Describe the components of an engine's operating system.

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, 10, 11)

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

Terms: The following terms are presented in this lesson (shown in bold italics and on PowerPoint Slides 2, 3, 4, and 5):

- Accessory systems
- Air cleaner
- Air cooled system
- Air intake system
- Battery-type ignition systems
- Breaker point-type battery system
- Breaker points
- Camshafts
- Carburetor
- Compression ignition system
- Condenser
- Cylinder head
- Distributor
- Distributor cam
- Electronic fuel injection systems
- Engine cooling system
- Exhaust manifold
- Exhaust system
- Exhaust valves
- Flywheel
- Fuel filter
- Fuel injection systems
- Fuel system
- Head gaskets
- Ignition coil
- Ignition system

- Intake valves
- Liquid cooling system
- Lubrication system
- Magneto-type ignition systems
- Mechanical fuel injection systems
- Operating systems
- Piston rings
- Primary system
- Pushrods
- Radiator
- Spark ignition systems
- Spring retainers
- Starting system
- Thermostat
- Valve guides
- Valve springs
- Water pump

Interest Approach:

Display a complete working small engine or multi-cylinder engine to the class. Have the students observe an engine in operation for a few minutes, then have them identify the major systems they observed.

SUMMARY OF CONTENT AND TEACHING STRATEGIES

Objective 1: Identify the three broad categories of internal combustion engine systems.

Anticipated Problem: What three broad categories can engine systems be divided into?

I. The internal combustion engine is a series of operating systems that work together to make the engine run. Each system performs its own functions. At the same time they must work together. Engine systems may be divided into three categories.

(PowerPoint Slide 6)

A. The ***primary system*** creates the engine compression and converts the energy of combustion to mechanical energy. The primary system is also referred to as the compression system.

B. The ***operating systems*** are those that perform the other engine functions. The engine will not operate without the operating systems. For example, an engine's electrical system is considered an operating system. Operating systems are also referred to as auxiliary systems.

C. ***Accessory systems*** are those that are not necessary for engine operation. An example of such a system is a power steering system. When a power steering system fails, the engine is still operable.

Display TM: 2-1 and use it to illustrate the different types of engines systems. By using an engine in your shop, identify different types of systems.

Objective 2: Identify the components of the primary or compression system.
Anticipated Problem: What parts make up an engine's primary or compression system?

(PowerPoint Slides 7 and 8)

II. The main purpose of an engine's primary or compression system is to efficiently compress air to increase the potential energy resulting from the combustion of the fuel. In order to understand the operation of a compression system, it is important to have knowledge of the components that make it up. The piston and cylinder must form a leak-proof combustion chamber for the engine to operate. The air tightness of the combustion chamber is a major design feature for the internal combustion engine. Combustion is usually lost in one of three places:

(PowerPoint Slides 9 and 10)

A. The fit of the piston in the cylinder—The piston cannot fit too tightly in the cylinder so that it can move freely up and down. As combustion occurs, the fuel-air mixture above the piston heats up and needs room for expansion. Pistons are usually machines from lightweight allows. The piston surfaces between the ring grooves are called lands. The bottom of the piston is called the skirt and the top is called the head or dome. The top of a piston can be one of three general shapes: flat, concave, or convex. ***Piston rings*** are made of cast iron and/or steel that fit near the top of the piston. The top piston rings are called compression rings. They help to prevent loss of compression during the compression stroke and prevent the loss of combustion pressure during the power stroke. The lower piston rings are called oil rings. These rings are designed to control the amount of oil on the cylinder walls. The rings have a spring action that provides a seal between the piston and the wall of the cylinder.

(PowerPoint Slides 11 and 12)

B. Head gasket—***Head gaskets*** provide a seal between the cylinder head and the cylinder block. The ***cylinder head*** forms the top of the combustion chamber. The cylinder block houses the cylinders and crankshaft. The head gaskets provide a tight seal for combustion of fuel to take place. When head gaskets go bad, the seal is broken and the combustion chamber is no longer leak-proof.

(PowerPoint Slides 13, 14, and 15)

C. Valves—An engine's valve assembly works with the pistons and engine block to perform compression and complete the events of internal combustion. The valve assembly is made up of several components. Problems with any of these components can lead to deficiencies in compression.
   1. ***Intake valves*** open and seal the intake ports.
   2. ***Exhaust valves*** open and seal the exhaust ports.
   3. ***Valve springs*** both close the valves and hold them open.
   4. ***Spring retainers*** hold the springs on the end of the valves.
   5. Valve guides support the valve stem as the valve moves back and forth.
   6. ***Camshafts*** open and close the valves.

7. ***Pushrods*** transfer the rotating movement of the camshaft to the linear movement of the valves. This is accomplished through the cam lobes and valve lifters or tappets which connect the camshaft to the pushrod.

Display TM: 2-2 to illustrate piston rings. TM: 2-3 displays a good basic example of a cylinder block for a small engine. TM: 2-4 gives a good illustration of the parts of an engine valve. Using an engine in your shop, identify the different parts of the engine in this objective.

Objective 3: Describe the components of an engine's operating system.

Anticipated Problem: What components make up an engine's operating system?

(PowerPoint Slides 16, 17, and 18)

III. An engine's operating systems are also known as the auxiliary systems. These systems perform the engine operating functions not handled by the primary or compression system. Components of the operating systems include:

(PowerPoint Slides 19 and 20)

A. The ***air intake system*** functions to provide a source of clean air necessary for the combustion of the air-fuel mixture.

1. Air must first be cleaned by passing through the ***air cleaner***. The air cleaner is a filtering device located on the outside of the engine. The two basic types of air cleaners used on today's internal combustion engines are dry element and oil foam.
2. The fuel and air are mixed in the carburetor. The ***carburetor*** provides fuel and air to the engine in the correct proportions and volume. Carburetors are still used on many gasoline-powered small engines. However, large gasoline-powered engines are fueled by injection systems. Fuel injection systems will be discussed under the fuel system.
3. The fuel-air mixture enters the engine cylinder through the intake valves, which open and close the intake ports located above the cylinders.

(PowerPoint Slide 21)

B. The ***fuel system*** delivers clean and adequate amounts of fuel to the cylinder.

1. The fuel tank is the area of storage for fuel. It can range in size from a few ounces to several gallons.
2. The ***fuel filter*** acts as a cleaner for the fuel that passes through it.
3. The fuel pump ensures that an adequate amount of fuel under the correct pressure is distributed throughout the rest of the system.
4. ***Fuel injection systems*** inject fuel into the combustion chamber or into the intake manifold. There are two basic types of fuel injection systems.
   a. ***Mechanical fuel injection systems*** use mechanical type pumps to inject high pressure fuel into the combustion chamber.
   b. ***Electronic fuel injection systems*** use electrically operated injectors to inject the fuel into either the combustion chamber or intake manifold.

(PowerPoint Slides 22 and 23)

C. The ***exhaust system*** removes the exhaust gases and particles from the combustion chamber. It also helps in managing engine noise and heat transfer. A basic exhaust system consists of the following components:
   1. The exhaust valve opens and closes the exhaust ports. The exhaust ports are the passages that the exhaust gases flow through. Several passages together are called the exhaust manifold. The ***exhaust manifold*** collects gases from one or more individual cylinders.
   2. The exhaust pipe is the tube that connects the exhaust manifold to the muffler. On some engines, there is no exhaust pipe. In this case, the muffler is mounted directly on the exhaust manifold.
   3. The muffler is a sound deadening device used to quiet engine operation. It also reduces or eliminates sparks in the exhaust gases.

(PowerPoint Slides 24, 25, and 26)

D. The ***engine cooling system*** is designed to manage the heat produced by the combustion of the air-fuel mixture. It is the task of the cooling system to allow the engine to reach its optimum operating temperature and to maintain that temperature under varying conditions. There are two basic types of cooling systems:
   1. The ***liquid cooling system*** uses a liquid to transfer heat from engine components to the surrounding air. Major components of a liquid cooling system include:
      a. A ***radiator*** is a heat transfer device that acts as a cooling an storage area for the liquid combination of water and antifreeze.
      b. The ***water pump*** is a mechanical device that forces the coolant to flow through the system.
      c. A ***thermostat*** is a flow control valve that regulates temperature inside an engine by opening and closing, thus regulating the liquid flow and cooling processes.
      d. Additional components of a liquid cooling system include the radiator cap, water jacket, fan, fan belt, and temperature gauge.
   2. An ***air-cooled system*** transfers the heat of the engine components directly to the surrounding air. Air-cooled systems are common on small engines. The basic parts of an air cooled system include:
      a. Fins are used to increase the surface area in contact with the air so that engine heat can be transferred more efficiently.
      b. The shroud is the engine cover that directs cooling air across the engine fins.
      c. A fan is used to force the air through the engine cooling system.
      d. The precleaner is usually a metal screen that filters the air for the cooling system.

(PowerPoint Slide 27)

E. The ***ignition system*** starts the combustion of the air-fuel mixture. There are two types of ignition systems.
   1. A ***compression ignition system*** does not consist of any unique parts. It is actually part of the compression system. The temperature needed to

burn the air an fuel mixture is provided by heat during the compression stroke or cycle.

2. ***Spark ignition systems*** use a high voltage electrical spark to ignite the compressed air and fuel mixture in the combustion chamber. The ignition system must create a spark with enough voltage to jump the gap of the spark plug and ignite the fuel. There are two types of spark ignition systems.

(PowerPoint Slide 28)

   a. ***Magneto-type ignition systems*** use magnets and coils to generate electrical pressure to arc the spark plug. In these systems, a flywheel magnet creates a magnetic field which cuts across the armature and coil assembly as the flywheel rotates, inducing voltage into the primary circuit. Current flow in the primary ignition circuit causes a magnetic field to build up around the coil's primary winding. The opening of the breaker points opens the primary ignition circuit, causing current flow to stop. Since no current is flowing the primary circuit, the magnetic field surrounding the coil's primary winding collapses. This collapsing magnetic field cuts across the coil's secondary winding, inducing voltage into the coil secondary. As the collapsing magnetic field cuts across the secondary winding, the voltage is increased. This process produces the high voltage necessary to cause a strong ignition spark across the spark plug gap.

(PowerPoint Slides 29, 30, and 31)

   b. ***Battery-type ignition systems*** use the energy from a battery and/or alternator to create the ignition spark. In a ***breaker point-type battery system*** an ignition switch begins the process by activating the battery with an ignition coil which starts the engine. The ***ignition coil*** is a cylinder shaped device that converts low battery voltage to a high voltage that is able to create a spark at the spark plug gap in an engine cylinder head. The ***distributor*** sends the high voltage current to the correct spark plug at the correct time. Within the distributor, the ***condenser*** functions as a capacitor which stores electrical energy. The ***breaker points*** provide a switch to initiate the spark in the engine. The ***distributor cam*** rotates inside of the distributor and controls the opening and closing of the breaker points, and regulates through the distributor rotor the timing of the engine spark.

(PowerPoint Slide 32)

F. The ***lubrication system*** keeps internal engine parts coated with oil to reduce friction, enhance cooling, seal internal engine components, and clean internal parts. An engine operating without proper lubrication even for a few seconds may have significant damage. Basic components of a lubrication system include:

   1. The oil filter removes dirt particles from oil
   2. A pressure regulator maintains the operating pressure of the lubrication system.

3. A sump is a reservoir for the engine oil. It is usually directly under the cylinder block and is more commonly called an oil pan.
4. The oil pump circulates oil through the engine.

(PowerPoint Slide 33)

G. The ***starting system*** is used to turn the engine crankshaft until the engine starts. It is designed to operate for a fairly short period of time. There are two basic types of engine starting systems.
   1. Manual starting systems are common on small engines. The engine is started by manually turning the crankshaft. This is most commonly accomplished through the use of a rope starter. This system uses a spring to rewind the rope after it has been pulled out to start the engine.
   2. Electrical staring systems are on many internal combustion engines. A solenoid-type switch controls the correct amount of voltage going to the starter. The ***flywheel*** is a large gear which is attached to the engine crankshaft. The starter motor is activated causing the starter shaft to engage and be matched with the flywheel gear teeth which turns over the engine. Upon releasing the starter switch from the start position, the starter disengages from the flywheel and the starter motor stops.

There is a good deal of information presented in this topic. Display TM: 2-5 to illustrate the major parts of an air intake system. TM: 2-6 provides a good depiction of the major parts of an exhaust system. TM: 2-7 gives a good example of the major parts of a liquid cooling system. TM: 2-8 provides a good illustration of a breaker point-type battery ignition system. Another method is to have the class identify the systems and components on an actual engine.

Review/Summary: The review and summary of the lesson may be accomplished by viewing the transparency masters with the students. **(PowerPoint Slide 34)** 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 Systems and Components LS: 2-1

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

Fill-in-the-blank

1. Exhaust manifold
2. Fuel filter
3. Breaker points
4. Accessory

Short Answer

1. The primary system creates the engine compression and converts the energy of combustion to mechanical energy. The primary system is also referred to as the compression system.
2. The fuel and air are mixed in the carburetor. The carburetor provides fuel and air to the engine in the correct proportions and volume. Carburetors are still used on many gasoline-powered small engines. However, large gasoline-powered engines are fueled by injection systems. Fuel injection systems will be discussed under the fuel system.

Sample Test

Identifying Engine Systems and Their Components

Name: _____

Matching: *Match each word with the correct definition.*

a. distributor cam	e. exhaust valve	i. radiator
b. lubrication system	f. intake valves	j. thermostat
c. carburetor	g. oil pump	k. muffler
d. distributor	h. ignition coil	l. condenser

_____ 1. A cylinder-shaped device that converts low battery voltage to a very high voltage.

_____ 2. Keeps internal engine parts coated with oil.

_____ 3. The sound deadening device used to quiet engine operation.

_____ 4. A flow control valve used to regulate the temperature inside the engine cooling system.

_____ 5. Part of the internal combustion engine that sends high-voltage current to the correct spark plug at the correct time.

_____ 6. Opens and closes the intake ports located above the cylinder.

_____ 7. Located inside the distributor this device functions as a capacitor which stores electrical energy.

_____ 8. Controls the opening and closing of the breaker points.

_____ 9. Engine part which functions in mixing the correct proportions and volume of fuel and air.

_____ 10. Mechanical device that circulates oil through the engine.

_____ 11. Opens and closes the exhaust ports.

_____ 12. Heat transfer device that acts as a cooling and storage area for the liquid combination of water and antifreeze.

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

1. The _____ _____ collects gases from one or more individual cylinders.
2. The _____ _____ acts as a cleaner for the fuel that passes through it.
3. _____ _____ provide a switch to initiate the spark in the engine.
4. The power steering system is an example of the _____ system.

***Short Answer**: Answer the following questions*.

1. What does the primary system do?

2. Describe the carburetor process.

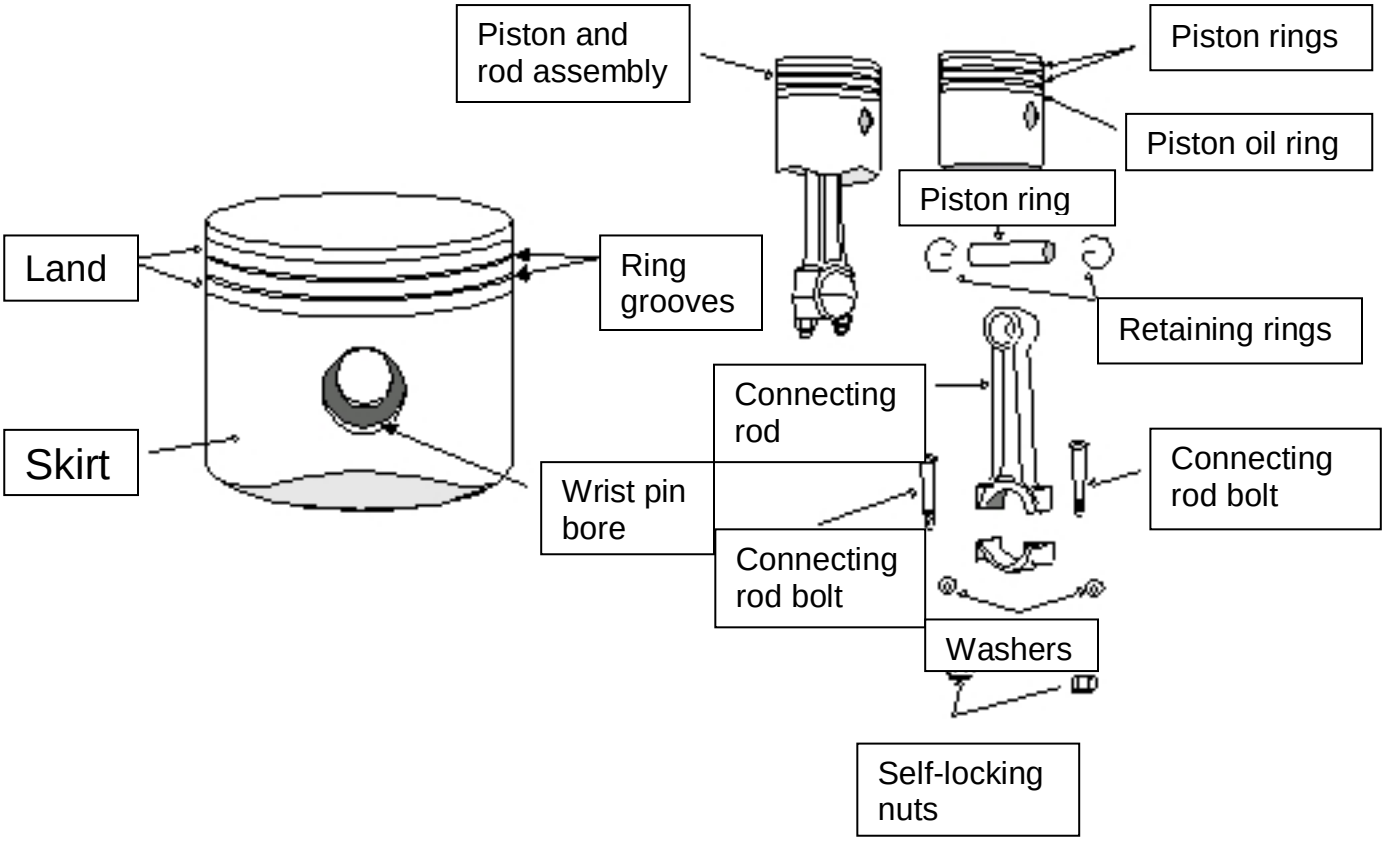
TM: 2-1

THREE CATEGORIES OF ENGINE SYSTEMS

1. **Primary system**—creates the engine compression and converts the energy of combustion to mechanical energy. Also called the compression system.
2. **Operating systems**—those that perform other functions. The engine will not operate without these systems. Also called the auxiliary systems.
3. **Accessory systems**—not crucial to engine operation.

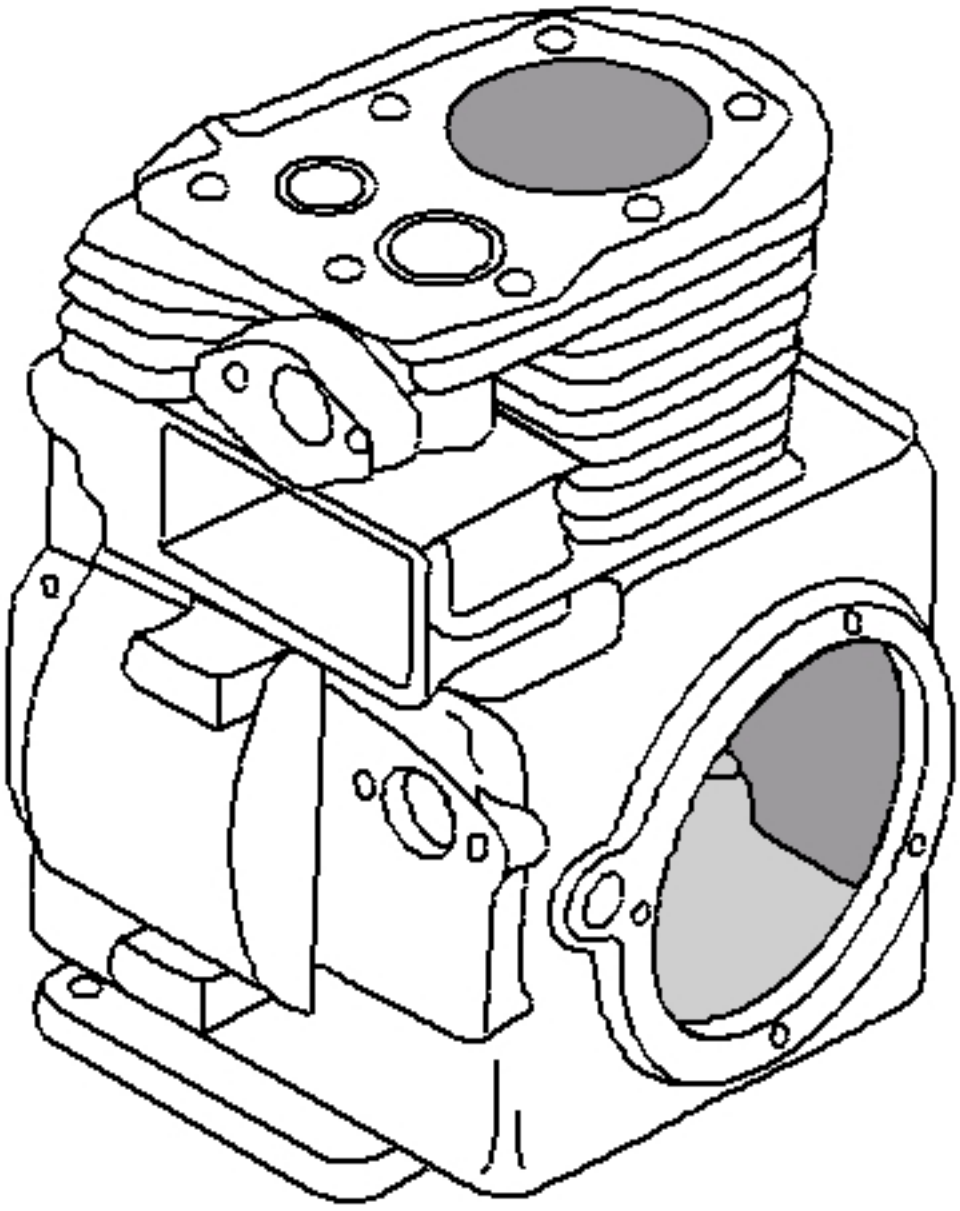
TM: 2-2

PISTON RINGS



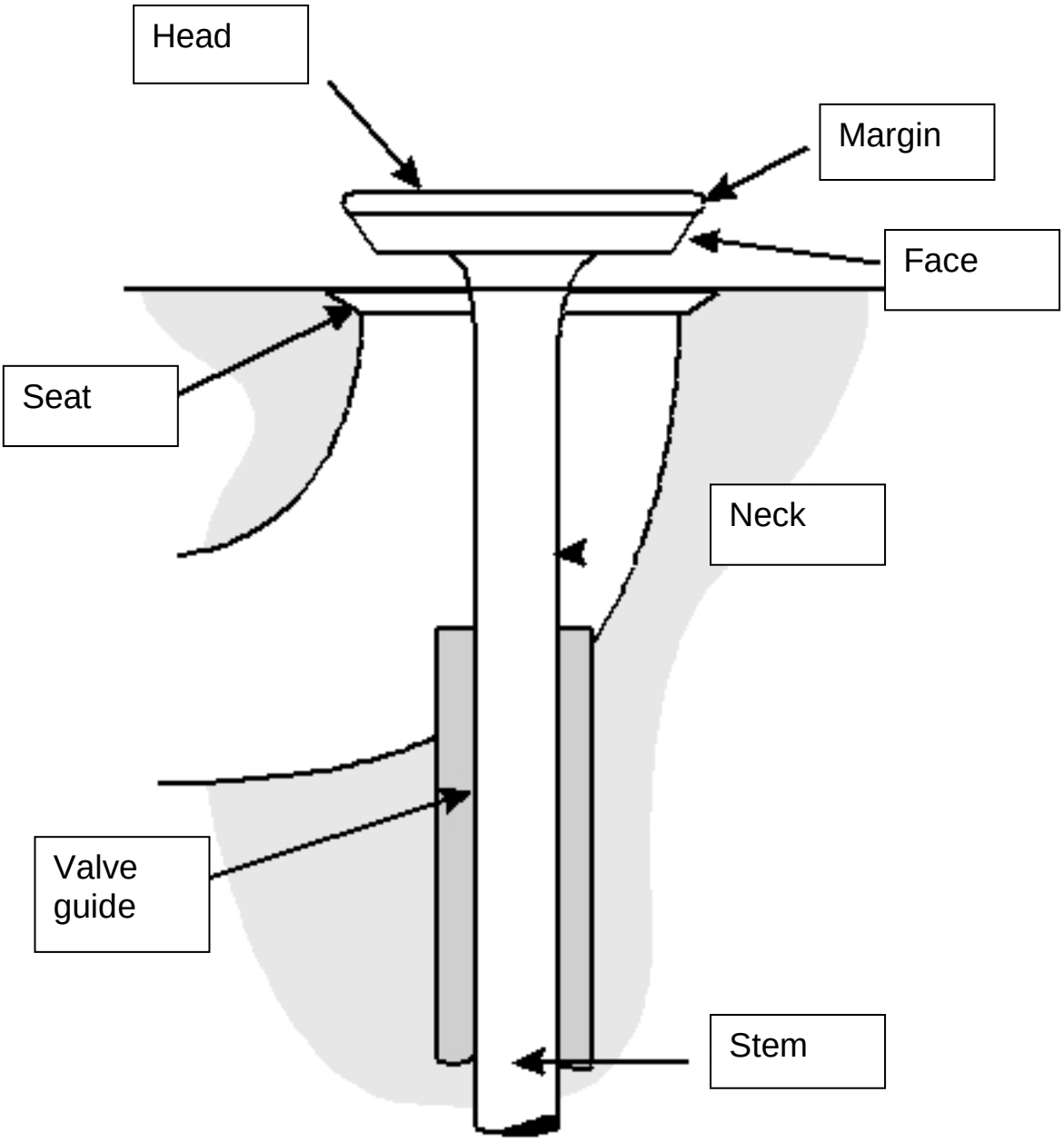
TM: 2-3

SMALL ENGINE CYLINDER BLOCK



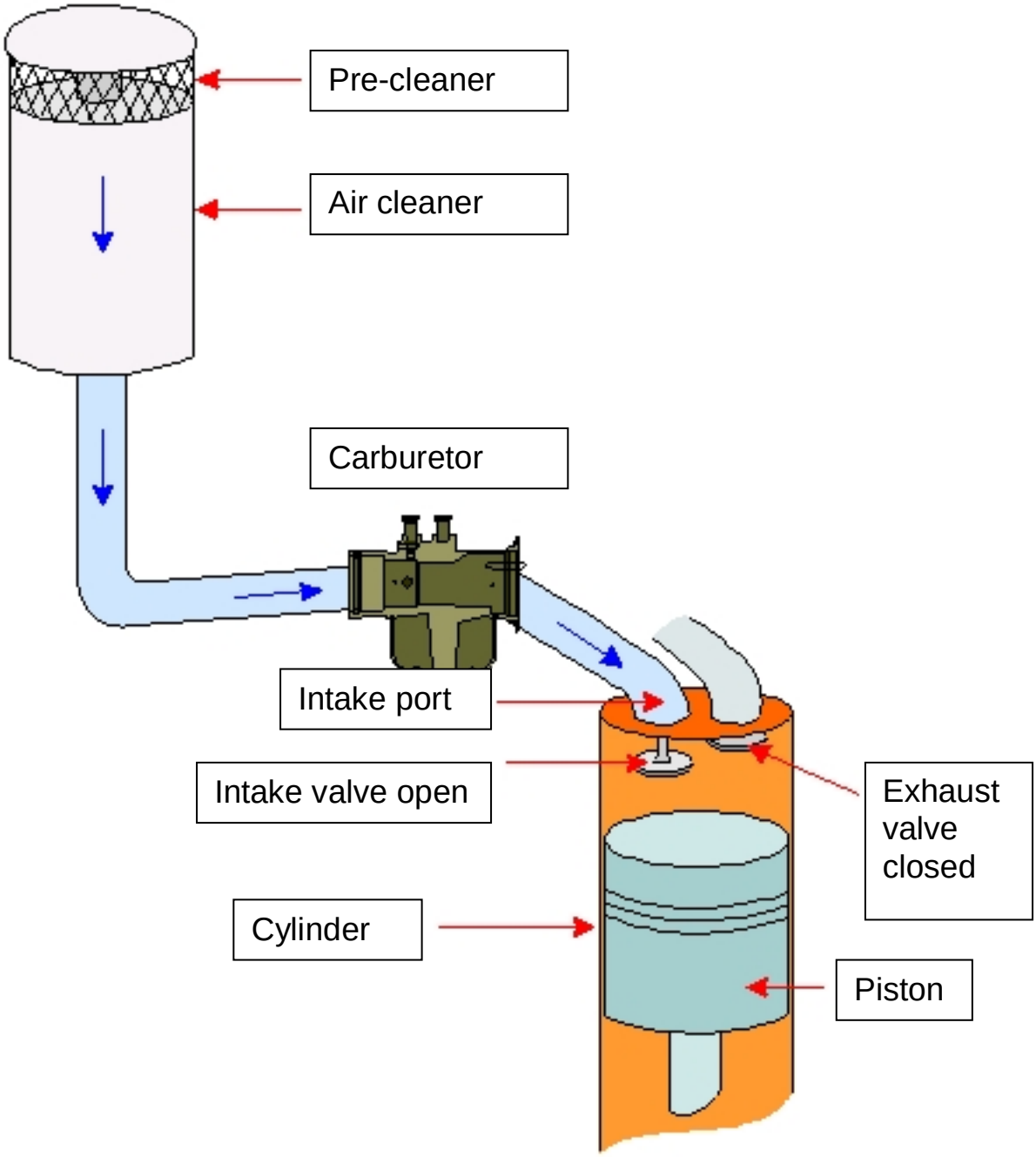
TM: 2-4

PARTS OF AN ENGINE VALVE



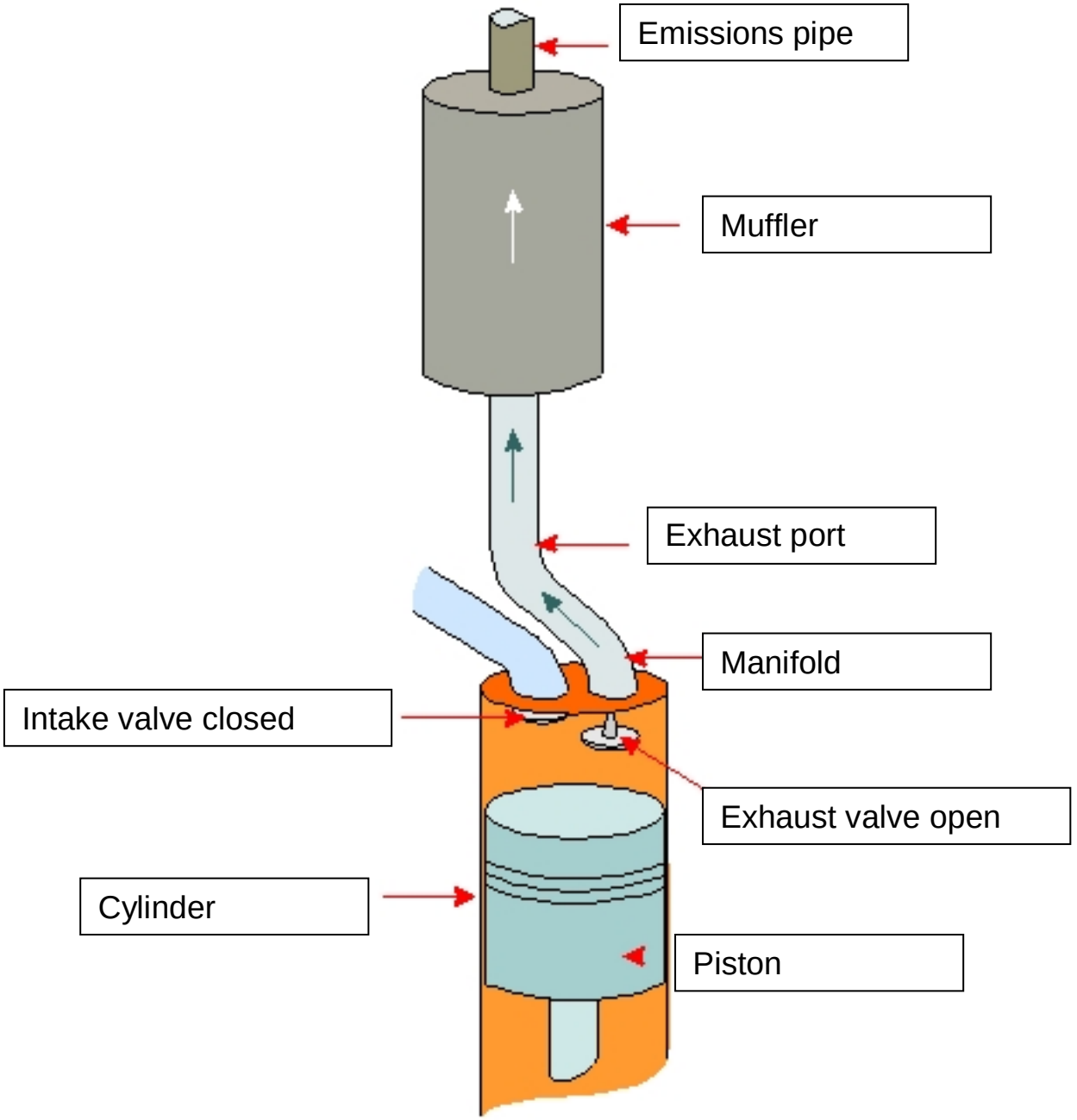
TM: 2-5

PARTS OF AN AIR INTAKE SYSTEM



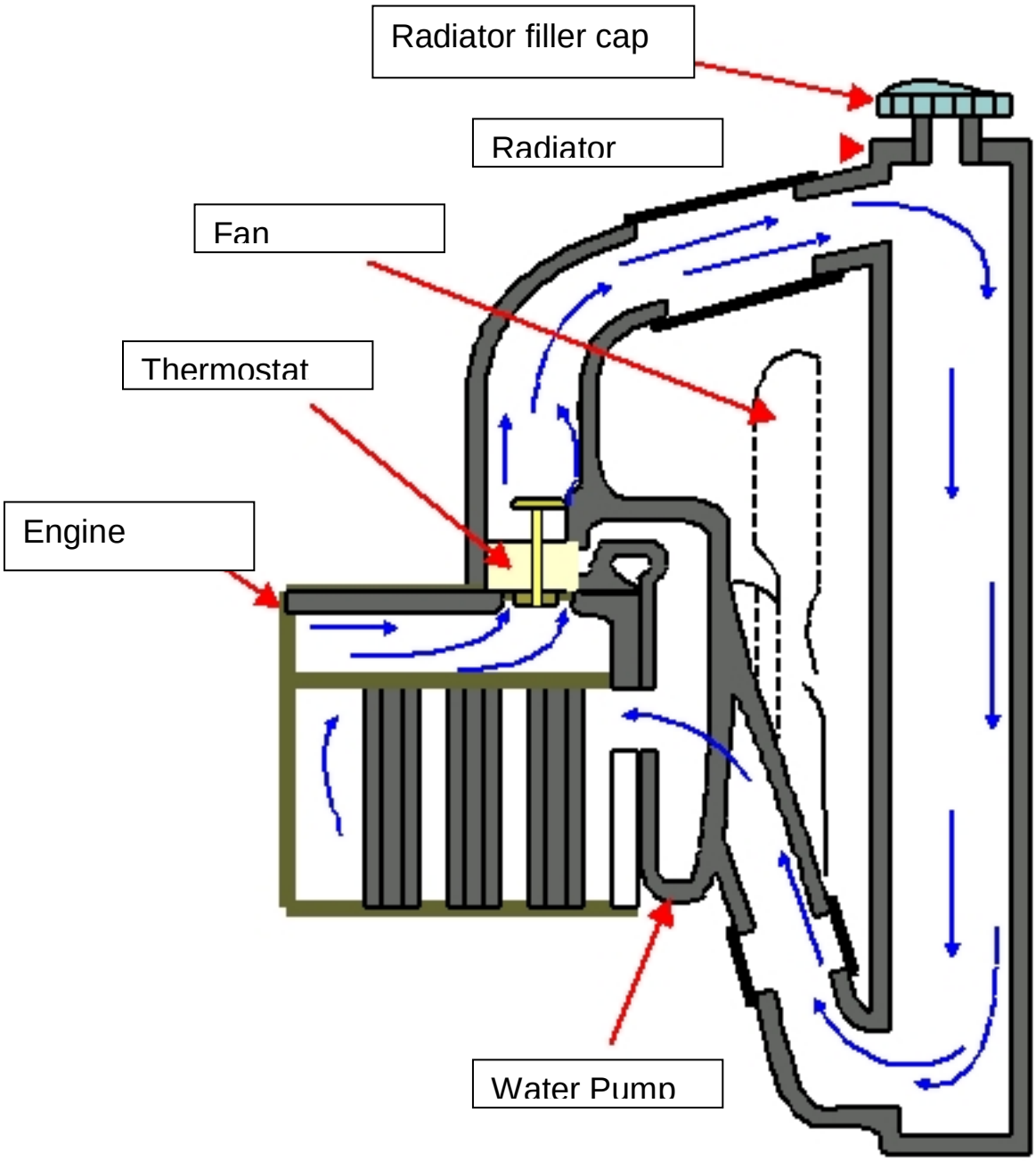
TM: 2-6

MAJOR PARTS OF AN EXHAUST SYSTEM



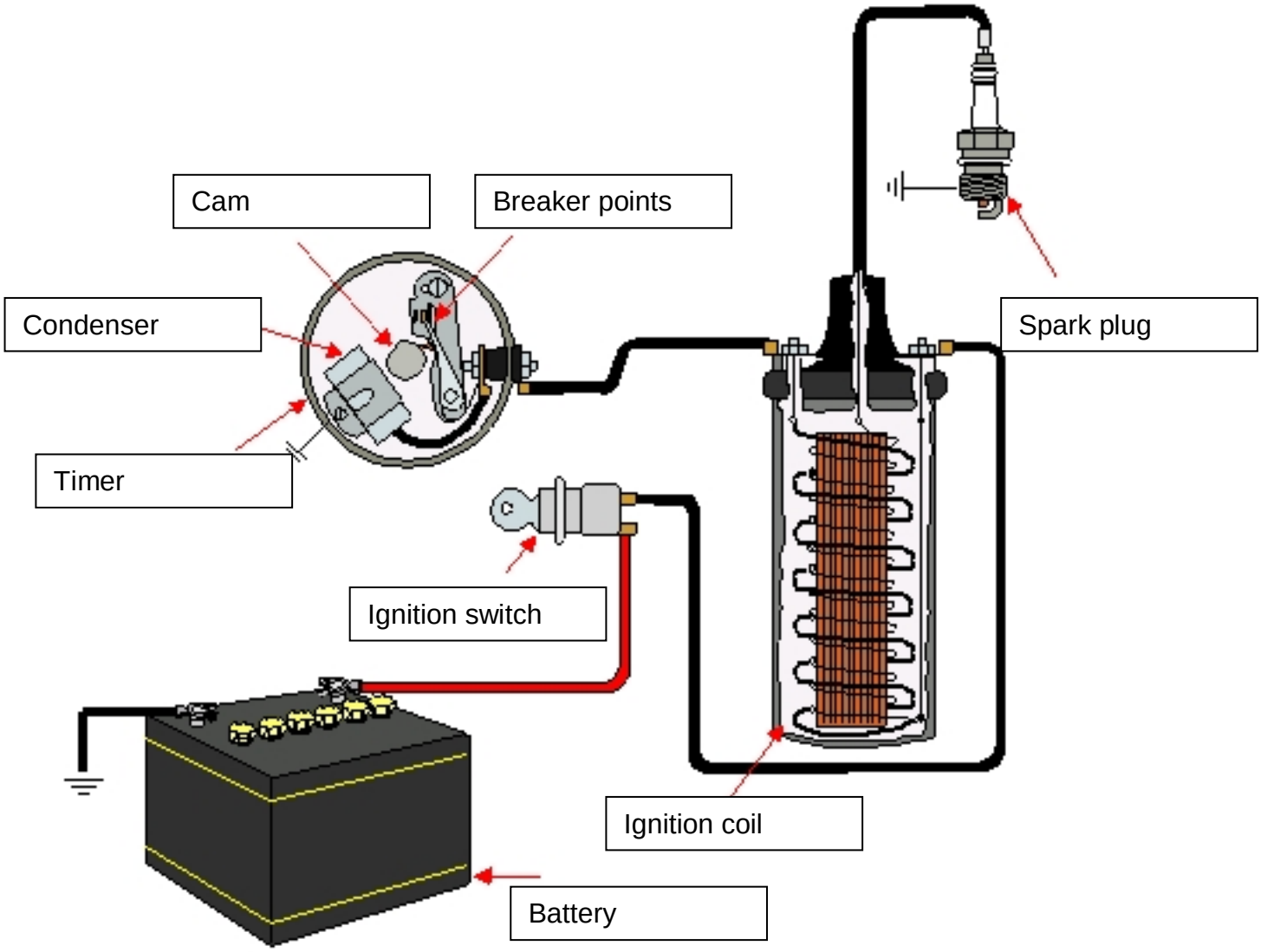
TM: 2-7

MAJOR PARTS OF A LIQUID COOLING SYSTEM



TM: 2-8

BREAKER POINT-TYPE BATTERY IGNITION SYSTEM



LS: 2-1

ENGINE SYSTEMS AND COMPONENTS

Instructions: Put the following engine parts in the correct systems.

Air cleaner
Battery
Breaker points
Carburetor
Coil
Condenser
Connecting rod
Cylinder
Cylinder head
Distributor
Flywheel
Fuel filter
Fuel pump
Piston
Rings
Spark plug
Starter

1. Primary (Compression) System: _____
   _____
   _____
2. Operating System: _____
   _____
   _____
3. Accessory System: _____
   _____
   _____
   _____