INTRODUCTION

This Teacher’s Guide provides information to help you get the most out of Fundamentals of Engine Operation. The contents in this guide will allow you to prepare your students before using the program and present follow-up activities to reinforce the program’s key learning points.

The Fundamentals of Engine Operation CD-ROM is a self-paced, computer-based learning program that explains the internal combustion process and the four-stroke cycle in detail. The program clearly identifies each major component of the engine and describes the operation of each component. The CD-ROM also describes the support systems of the engine, including the oil system and the cooling system.

According to the Bureau of Labor Statistics, job opportunities in the automotive service field are expected to be on the rise for persons who complete automotive training programs in high school, vocational and technical schools, or community colleges. Employment of automotive service technicians and mechanics is expected to increase about 10 to 20 percent through the year 2010. Use the Fundamentals of Engine Operation CD-ROM and accompanying activities provided in this guide to provide students with a thorough understanding of how an engine works, and to prepare students for potential careers in this field.

LEARNING OBJECTIVES

After viewing the program, students will be able to:

- Identify the four strokes of the combustion cycle.
- Describe the function and operation of the engine block assembly.
- Identify two types of valve trains.
- Describe the function and operation of the valve train.
- Explain the purpose of the oil system.
- Describe the characteristics of engine oil.
- Explain the purpose of the cooling system.
- Describe how coolant flows through the engine.

EDUCATIONAL STANDARDS

This CD-ROM correlates with the Program Certification Standards for Automobile Technician Training Programs from the National Institute for Automotive Service Excellence (ASE) and the National Automotive Technicians Education Foundation (NATEF). The content has been aligned with the following educational standards and benchmarks from these organizations.

Introduction to Auto Shop and Personal Safety

- Identify general shop safety rules and procedures.
- Utilize safe procedures for handling of tools and equipment.
- Identify and use proper placement of floor jacks and jack stands.
Identify and use proper procedures for safe lift operation.

Utilize proper ventilation procedures for working within the lab/shop area.

Identify marked safety areas.

Identify the location and use of fire blankets.

Identify the location and the types of fire extinguishers; demonstrate knowledge of the procedures for using fire extinguishers.

Identify the location and use of eye wash stations.

Identify the location of the posted evacuation routes.

Comply with the required use of safety glasses, gloves, shoes during lab/shop activities.

Identify and wear appropriate clothing for lab/shop activities.

Comply with appropriate hairstyles for lab/shop activities.

Tools and Equipment

Identify tools and their usage in automotive applications.

Identify standard and metric designation.

Demonstrate safe handling and use of appropriate tools.

Demonstrate proper cleaning, storage, and maintenance of tools and equipment.

General Engine Diagnosis

Identify and interpret engine concern; determine necessary action.

Research applicable vehicle and service information, such as internal engine operation, vehicle service history, service precautions, and technical service bulletins.

Inspect engine assembly for fuel, oil, coolant, and other leaks; determine necessary action.

Diagnose engine noises and vibrations; determine necessary action.

Diagnose the cause of excessive oil consumption, unusual engine exhaust color, odor, and sound; determine necessary action.

Perform cylinder compression tests; determine necessary action.

Perform cylinder leakage tests; determine necessary action.

Cylinder Head and Valve Train Diagnosis and Repair

Remove cylinder head(s); visually inspect cylinder head(s) for cracks; check gasket surface areas for warpage and leakage; check passage condition.

Inspect valve springs for squareness and free height comparison; check passage condition.

Inspect valve guides for wear; check valve stem-to-guide clearance; determine necessary action.

Inspect valves and valve seats; determine necessary action.

Check valve face-to-seat contact and valve seat concentricity (runout); determine necessary action.

Check valve spring assembled height and valve stem height; determine necessary action.

Check valve spring assembled height and valve stem height; determine necessary action.

Inspect pushrods, rocker arms, rocker arm pivots and shafts for wear, bending, cracks, looseness, and blocked oil passages (orifices); determine necessary action.

Adjust valves (mechanical or hydraulic lifters).

Inspect and replace timing belts (chains), overhead camdrive sprockets, and tensioners; check belt/chain tension; adjust as necessary.

Inspect camshaft for runout, journal wear, and lobe wear.
Inspect camshaft bearing surface for wear, damage, out-of-round, and alignment; determine necessary action.

**Engine Block Assembly Diagnosis and Repair**
- Disassemble engine block; clean and prepare components for inspection and reassembly.
- Inspect engine block for visible cracks, passage condition, core and gallery plug condition, and surface warpage; determine necessary action.
- Inspect and measure cylinder walls for damage, wear, and ridges; determine necessary action.
- Identify piston and bearing wear patterns that indicate connecting rod alignment and main bearing bore problems; inspect rod alignment and bearing bore condition.
- Remove and replace piston pin.
- Inspect, measure, and install piston rings.
- Assemble the engine using gaskets, seals, and formed-in-place (tube-applied) sealants, thread sealers, etc. according to manufacturer’s specifications.

**Lubrication and Cooling Systems Diagnosis and Repair**
- Perform oil pressure tests; determine necessary action.
- Inspect oil pump gears or rotors, housing, pressure relief devices, and pump drive; perform necessary action.
- Perform cooling system, cap, and recovery system tests (pressure, combustion leakage, and temperature); determine necessary action.
- Inspect, replace, and adjust drive belts, tensioners, and pulleys; check pulley and belt alignment.
- Inspect and replace engine cooling and heater system hoses.
- Inspect, test, and replace thermostat and housing.
- Test coolant; drain and recover coolant; flush and refill cooling system with recommended coolant; bleed air as required.
- Inspect, test, remove, and replace water pump.
- Remove and replace radiator.
- Inspect, and test fans(s) (electrical or mechanical), fan clutch, fan shroud, and air dams.
- Inspect auxiliary oil coolers; determine necessary action.
- Inspect, test, and replace oil temperature and pressure switches and sensors.
- Perform oil and filter change.

**Language Arts Standards***
The activities in this Teacher’s Guide were created in compliance with the National Standards for the English Language Arts from the National Council of Teachers of English. Using these standards, the ASE/NATEF organizations have compiled the following list of language arts and communication skills for automotive service personnel.

Using these skills, an automotive technician must be able to:
- Request, collect, comprehend, evaluate, and apply oral and written information gathered from customers, associates, and supervisors regarding problem symptoms and potential solutions to problems.
- Identify the purpose for all written and oral communication and then choose the most
effective strategies for listening, reading, speaking, and writing to facilitate the communication process.

- Adapt a reading strategy for all written materials, e.g. customer’s notes, service manuals, shop manuals, technical bulletins, etc., relevant to problem identification, diagnosis, solution, and repair.
- Attend to verbal and nonverbal cues in discussions with customers, supervisors, and associates to verify, identify, and solve problems.
- Use study habits and techniques, i.e. previewing, scanning, skimming, taking notes, etc., when reviewing publications (shop manuals, references, databases, operator’s manuals, and text resources) for problem solving, diagnosis, and repair.
- Use prior knowledge learned from solving similar problems to diagnose and repair specific problems.
- Write clear, concise, complete, and grammatically accurate sentences and paragraphs.
- Write warranty reports and work orders to include information regarding problem resolution and the results of the work performed for the customer or manufacturer.
- Comprehend and apply industry definitions and specifications to diagnose and solve problems in all automotive systems and components.
- Follow all oral/written directions that relate to the task or system under study.
- Comprehend and use problem-solving techniques and decision trees that are contained in service manuals to determine cause-and-effect relationships.
- Scan service manuals and databases to locate specific information for problem-solving purposes.
- Use the service manual to identify the manufacturer’s specifications for system parameters, operation, and potential malfunctions.
- Interpret charts, tables, or graphs to determine the manufacturer’s specifications for system operation to identify out-of-tolerance systems and subsystems.
- Supply clarifying information to customers, associates, parts suppliers, and supervisors.

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Technology Standards
The activities in this Teacher’s Guide were created in compliance with the National Education Technology Standards from the National Education Technology Standards Project.

- Students are proficient in the use of technology.
- Students use technology tools to enhance learning, increase productivity, and promote creativity.
- Students use productivity tools to collaborate in constructing technology-enhanced models, prepare publications, and produce other creative works.
- Students use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences.
- Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences.
- Students use technology to locate, evaluate, and collect information from a variety of sources.
PROGRAM OVERVIEW

This CD-ROM introduces the basic concept of engine performance. By covering the purpose, function, and operation of the primary automotive systems involved in engine performance—ignition, fuel, exhaust, and emissions—this program explains how the performance of an automobile can be optimized while the emissions produced are minimized. On-board diagnostics II (OBD-II), which monitors vehicle conditions associated with excessive emissions, is also introduced.

MAIN TOPICS

**Topic 1: Introduction**
The Introduction provides an overview of what the course will cover, listing the lesson names and their significance. The introduction is designed to spark interest in the course and motivate the user to want to view the rest of the course. The objectives of the course are also identified.

**Topic 2: Four-Stroke Combustion Cycle**
The Four Stroke Combustion Cycle lesson defines the term combustion and describes the four-stroke cycle internal combustion engine: intake, compression, power, and exhaust.

**Topic 3: Engine**
The Engine lesson identifies the components of the engine lock assembly and the valve train, and explains the function and operation of each component.

**Topic 4: Oil System**
The Oil System lesson describes the oil system and its components, explains the importance of the oil system to the overall operation of the engine, and explains how oil circulates through the system.

**Topic 5: Cooling System**
The Cooling System lesson describes the components and functionality of the cooling system, explains the importance of the cooling system to the overall operation of the engine, and describes the properties and purpose of coolant fluid.

**Topic 6: Final Review**
The Final Review includes an interactive assessment covering the objectives of the course.

FAST FACTS

- Another name for the four-stroke combustion cycle is the Otto cycle, named for the German engineer Dr. Nicolaus August Otto, who in 1876 built the first successful four-stroke engine. He first built this Otto cycle engine into a motorcycle.
- The starting system actually starts a vehicle by causing the crankshaft to rotate. An electrical motor called the starter turns the flywheel, which turns the crankshaft. Once the crank-
shaft is rotating, the force created during the power stroke of the combustion process occurring alternately in each cylinder keeps the crankshaft rotating.

- In the late 1920’s, some automobiles had in-line engines that had as many as 16 cylinders! These engines were very large and resulted in vehicles with very long front ends. The sheer size of in-line engines inspired the development of other engine configurations that could yield the same power and take up less space.

- The piston ring is perhaps the hardest working component in the engine. Why? Because it takes the direct force of 850 pounds per square inch (psi) and temperatures in excess of 1800° F during the power stroke, as well as constant friction from the up and down movement inside the cylinder walls. Depending on engine speed, this up and down movement can occur well in excess of 1000 times per minute per cylinder.

- Main bearings are designed to wear down before the crankshaft. The lead-coated copper or tin aluminum that the main bearings are made of is softer than the cast-iron crankshaft. As a result, the bearings will show damage or wear first. If caught soon enough, replacement can be limited to the bearings, sparing the crankshaft.

- When you hear of an automobile with a dual overhead cam engine or see DOHC on the side of a vehicle, it means that the engine uses two overhead camshafts to drive the valve train. Typically, an engine using dual overhead camshafts has four valves per cylinder—two intake and two exhaust.

- Before the introduction of multi-grade oils, vehicle owners living in changing climates had to switch the oil in their vehicles from higher viscosity oil in the warmer seasons to lower viscosity oil in the colder months.

- A Canadian inventor named Thomas Ahearn invented the first electric car heater in 1890.

- Early internal combustion engines were air-cooled instead of liquid-cooled. With air-cooled engines, there were no concerns about engines freezing because there was no coolant inside of them to freeze. Without liquid coolant, however, the passenger compartment could not be heated because the heat for the passenger compartment came from the hot coolant.

- After an engine block is cast, there are holes left in the block that are filled with stoppers called core plugs or freeze plugs. These plugs are made of a soft metal. If the coolant in an engine block freezes, the coolant expands. The expansion of the coolant could cause the block to crack. Instead, in some cases the freeze plugs pop out if the block expands, which can possibly save the engine block.

**VOCABULARY TERMS**

**Aluminum alloy:** A metal that is formed from aluminum and another metal, which alters the pure metal’s properties such as strength, elongation, and weight.

**Bearing clearance:** The distance between the bearings and the crankshaft.

**Blow-by:** A condition that results when the compression rings do not prevent the combustion gases from slipping past the rings and into the crankcase during the power stroke.

**Bottom Dead Center (BDC):** The lowest point of piston and connecting rod travel in a cylinder; ends the intake and power strokes in a four-cycle engine.

**Compression ratio:** The volume of fuel and air when the piston is at BDC, compared to the volume at TDC.
**Crankcase**: The part of the engine that surrounds the crankshaft. Different from the pan, which simply covers the crankcase.

**Cylinder**: The hollow tubular cavity in the cylinder block in which the piston travels and in which combustion takes place. Typically made of cast iron and formed as a part of the block.

**Cylinder head**: The aluminum or iron casting that houses the combustion chambers, the intake and exhaust ports, and much or all of the valve train. The head (or heads, if an engine has more than one bank of cylinders) is always directly above the cylinders.

**Cylinder liners**: A hardened steel cylinder that is inserted into the engine block made to contain combustion inside the cylinders and reduce wear from piston ring movement.

**Displacement**: The total volume of air that is moved, or displaced, by all the cylinders when the pistons move from bottom dead center to top dead center. Cylinder displacement is the volume of air that is moved by one cylinder.

**Engine block assembly**: The components of the engine including the block, the pistons, connecting rods, and crankshaft, which work together to turn the crankshaft.

**Exhaust port**: Passages that let exhaust gases out after the mixture has burned.

**Flywheel**: A heavy circular device on the end of the crankshaft that balances out the rotation of the crankshaft.

**Four stroke combustion cycle**: An internal-combustion engine that requires two revolutions per cylinder, or four piston strokes, to achieve an intake stroke, compression stroke, power stroke, and exhaust stroke; more efficient than the two-stroke cycle engine; also called the Otto cycle.

**Heater core**: A small radiator that circulates hot coolant that is transferred to the air and directed into the passenger compartment to provide warmth for the passengers.

**Intake port**: Passages that let the air-fuel mixture into the cylinders and let exhaust gases out after the mixture has burned.

**Piston**: A partly hollow, cylindrical metal engine part that is closed at one end and fits into the engine cylinder. It is connected to the crankshaft via the connecting rod and usually fitted with rings to seal it in the cylinder.

**Piston clearance**: The distance between the outside edge of the piston and the cylinder wall.

**Piston pin**: A steel pin that allows the piston to pivot on the small end of the connecting rod.

**Piston rings**: Split rings installed in grooves in the piston. Piston rings seal the combustion chamber from the crankcase.

**Rod cap**: A metal cap that connects the large end of the connecting rod to the crankshaft.

**Top Dead Center (TDC)**: The highest point of piston and connecting rod travel in a cylinder; ends the compression and exhaust strokes in a four-cycle engine.

**Valve face**: The part of the valve that comes in contact with the valve seat.

**Valve lift**: The distance a valve is lifted from the valve seat when fully open.

**Valve seat**: An insert that is pressed into the cylinder head; the valve face of the valve contacts the valve seat.

**Valve train**: The components of the engine that work together to open and close the intake and exhaust valves; depending on the type of valve train, this includes the camshaft, lifters, pushrods, rocker arms, and other components.

**Viscosity**: A characteristic of engine oil that indicates its ability to flow at a specific temperature.
PRE-PROGRAM DISCUSSION QUESTIONS

Use the following questions with students before they view the program. These questions will help to start students thinking about the uses for engines and how engines operate, and spark an interest in the content of the program. The questions may be used in a classroom setting or provided for students to consider on their own.

1. Besides automobiles, trucks, and busses, name at least five other things that use an engine to operate.
2. What are some of the important things an engine needs to operate? Why do you think these things are critical to making an engine work?
3. Think about your favorite car or racecar. What are some of the things that this car’s engine has that makes it different or special? What are some of the specifications or common terms you hear mentioned about this car’s engine? What do those terms mean?
4. Combustion and the combustion cycle are critical to engine operations. What do you think the word “combustion” means? Why do you think this is critical to making an engine perform? Can you name any other systems or devices that use combustion for energy?
5. In your “fantasy” car (i.e., a car that either exists or one you wish you could create), what kinds of things would your engine be able to do? How would it do these things? What kinds of components or systems would your engine have?

POST-PROGRAM DISCUSSION QUESTIONS

Use these questions with students after viewing the program. These questions will encourage students to think about the subject matter presented in the program and apply what they have learned, as well as think beyond the core content. These questions may be used in a classroom setting or for students to consider on their own.

1. What are the main functions of oil and the oil system in an automobile? Why are oil and the oil system so critical to the operation of an engine?
2. What do you think would be the most difficult component of the engine to repair? What would be the easiest? Why?
3. What kinds of safety precautions do you think would be needed when checking or repairing an engine? Why? What kinds of hazardous materials might be a part of these safety considerations?
4. Explain the four-step combustion process in detail. What are the names of the four strokes? How do they work? How does combustion make an engine move?
5. What are the primary types of engines that exist today? If you had your choice of working with or repairing only one type of engine for your entire life, what would it be and why?
GROUP ACTIVITIES

The Checkered Flag
Organize the class into small groups. Have each group choose a favorite type of racecar, and research the engine configuration. Create a chart detailing the specifications of the racecar engine, including the engine configuration, torque, horsepower, components, which engine components claim to be fastest, best performing, most efficient, least likely to break down, etc. Using this specifications chart, prepare a short, convincing argument or presentation about why the racecar chosen has the best engine. Each group should present their charts and arguments to the class, explaining why their car is truly the one that would win the race (i.e., “the best”). The instructor should proclaim the most convincing argument the “winner” of the race.

Is Your System “Cool?”
The cooling system is one of the most important subsystems on an automobile. Working in small groups, create a “Repair Manual for Dummies” including pictures, lists and pictures of tools, and step-by-step “how to” instructions that describe how to safely handle, check, fix, or maintain a critical component (or the overall functioning) of the cooling system. Potential topics include:

- How to Check Coolant Circulation
- Safely Handling, Changing, and Recycling Coolant Fluid
- Quick Fixes for Overheating
- Checking and Repairing Radiators
- Changing Thermostats
- Replacing a Water Pump
- Flushing a Cooling System
- Cooling System Additives—Purpose, Function, Advantages, Disadvantages

Picture This
Working in small groups, prepare a children’s picture book that explains one of the major systems/components presented in the Fundamentals of Engine Operations in a simple format for children. (The main topic of the book should be very focused, such as the engine block, valve train, oil system, or cooling system.) The pictures in the book should include a very simple (for kids!) definition of the components in the system, a description of the how of each component works, and how the components work together in the operation of the system. Students should have the option to use a title and story format that would appeal to children (for example, a possible story title could be The Little Engine that Could —and Here’s Why He Could!).

As an optional part of this project, the groups can take a field trip to a local elementary school and read the book to children to see their reaction and determine whether the kids understand how an engine works as a result of the reading. (The principle behind this exercise is for the students to think about the parts and operation of an engine in the simplest terms, so that they can master the basics of engine operations.)
INDIVIDUAL STUDENT PROJECTS

The Configuration Challenge
The Fundamentals of Engine Operations program introduces two common consumer engine block configurations, including Inline designs and V designs. Racecars, machinery, trucks, and other vehicles use other types of engine configurations to fulfill their purpose. Research the different types of engine configurations that are currently used in automobiles, racecars, trucks, or other vehicles. Choose two configurations not discussed in the program (i.e., do NOT choose Inline or V configurations) and explain each. Be sure to describe the following:

• Engine block design (shape, size, etc.)
• Cylinders, pistons, and other components
• How the configuration works
• Where/when the configuration is commonly used (i.e., in which types of vehicles and for what purpose)
• Advantages/disadvantages of the configuration
• Major differences in this configuration from the two common configurations discussed in the CD-ROM program

(Note to Teacher: Possible configurations students may choose from include flat four-cylinder, electric, diesel, rotary, steam, and others)

Fill It Up!
Research the different types of fuels available and different types of engines that these fuels propel. Choose three different types of fuels and create a chart comparing and contrasting the properties of these fuels.

For each fuel, describe the following:

• How is the fuel obtained or made? (Where does it come from?)
• What are the advantages and disadvantages of the fuel?
• Is the fuel widely used or rare?
• What kind of engines does the fuel propel?
• What are the main components in the engine that allow the fuel to work?
• What are the primary types of vehicles that use the fuel/engine?

I’m Going to Combust
Besides the automobile engine, name two other devices or systems that use a combustion process to create energy, motion, or reactions. How are the processes in these devices or systems similar to the process in the four-stroke combustion cycle? How are they different?

Prepare a chart or poster to compare and contrast the combustion processes for the automobile and for the systems or devices that you choose.
INTERNET ACTIVITIES

Engine Scavenger Hunt
In this activity, students use the Internet to research engine-related questions. To help them get started, direct students to http://auto.howstuffworks.com

Give students the following assignment:

Name three things that can cause a lack of compression in a car engine.

**Answers:**
1. Your piston rings are worn, allowing air/fuel to leak past the piston during compression.
2. The intake or exhaust valves are not sealing properly, again allowing a leak during compression.
3. There is a hole in the cylinder.

Name three reasons why almost all cars today use a reciprocating internal combustion engine.

**Answers:**
1. It's relatively efficient (compared to an external combustion engine).
2. It's relatively inexpensive (compared to a gas turbine).
3. It's relatively easy to refuel (compared to an electric car).

Why do high-performance cars generally need high-octane gasoline?

**Answer:** Higher compression ratios produce more power, up to a point. The more you compress the air/fuel mixture, however, the more likely it is to spontaneously burst into flame (before the spark plug ignites it). Higher-octane gasolines prevent this sort of early combustion. That is why high-performance cars generally need high-octane gasoline — their engines are using higher compression ratios to get more power.

What is the difference between a gasoline engine and a diesel engine?

**Answer:** In a diesel engine, there is no spark plug. Instead, diesel fuel is injected into the cylinder, and the heat and pressure of the compression stroke cause the fuel to ignite. Diesel fuel has a higher energy density than gasoline, so a diesel engine gets better mileage.

What does it mean if a car is normally aspirated?

**Answer:** In the air intake system, most cars are normally aspirated, which means that air flows through an air filter and directly into the cylinders.

Engine History Timeline
Engine configurations and components have changed dramatically since the invention of the automobile. Using the Internet, research the history of the automobile engine, paying careful attention to major milestones or innovations over the years. Prepare a poster timeline (or chart) that shows the major milestones and innovations in the evolution of the automobile engine.
Provide students with the following websites to begin their research:

**Automobile History—The History of Cars and Engines**  
http://inventors.about.com/library/inventors/blcar.htm

**The History of the Automobile—Gas Engines**  
http://inventors.about.com/library/weekly/aacarsgasa.htm

**The First Car—A History of the Automobile**  
www.ausbcomp.com/~bbott/cars/carhist.htm

**The History Channel Online**  
www.historychannel.com

**About.com History of the Automobile**  
http://inventors.about.com/library/weekly/aacarsgasa.htm

(Note that students will find many related websites by visiting any search engine and typing in the phrase “history of automobiles” or “history of cars + engines.”)

**Key Innovators Behind the Engine**  
Nicolaus Otto, Karl Benz, Gottlieb Daimler, and Wilhelm Maybach are often cited as four of the most important innovators in the history of engines and the automobile. Use the Internet to research the contributions of one of these critical innovators. Prepare a biography about your chosen inventor and his contributions. This biography can be presented in a traditional report format, or can be presented as a poster/timeline, illustrated book, or other creative format. In your bibliography, be sure to describe the following:

- Who was this person and where were they from?
- What was their critical contribution/invention for automobile and engine design?
- What influenced this person’s innovations?
- What types of cars/products resulted from this person’s innovations?
- What principles or products from this person’s invention are still used today?

Students can begin researching these inventors on the About.com History of the Automobile Website at http://inventors.about.com/library/weekly/aacarsgasa.htm.
**ASSESSMENT QUESTIONS**

The following Assessment Questions will allow teachers to test the students’ understanding and comprehension of the program’s content.

**Q:** Where does combustion take place in the engine?
   (a) Cylinder  
   (b) Intake valve  
   (c) Piston  
   (d) Crankshaft  
**A:** (a) Cylinder

**Feedback:** Combustion occurs in the cylinder, which is a hollow cavity bored into the engine block.

**Q:** Which engine component houses the pistons and connecting rods?
   (a) The valve train  
   (b) The cylinder head  
   (c) The cylinder  
   (d) The engine block  
**A:** (d) The engine block

**Feedback:** The engine block houses the crankshaft, connecting rods, and pistons.

**Q:** During the ________ stroke of the four-stroke combustion cycle, the air-fuel mixture enters the combustion chamber.
**A:** intake

**Feedback:** During the intake stroke, the air-fuel mixture enters the combustion chamber through the intake valve.

**Q:** Which of the following terms refers to the volume of air, in liters, that is moved in a piston from bottom dead center to top dead center?
   (a) Valve clearance  
   (b) Displacement  
   (c) Compression ratio  
   (d) Piston clearance  
**A:** (b) Displacement

**Feedback:** Displacement refers to the total volume of air moved, or displaced, by all the cylinders from piston movement.

**Q:** Which component is NOT a part of the valve train?
   (a) The valve  
   (b) The rocker arm  
   (c) The crankshaft  
   (d) The lifter  
**A:** (c) The crankshaft

**Feedback:** The crankshaft is part of the engine block assembly.
Q: Describe the purpose of the valve train.
A: The components in the valve train work together to open and close the intake and exhaust valves.

Q: Which is a true statement about the overhead valve train?
   (a) The camshaft is located in the cylinder head.
   (b) It requires pushrods to move the rocker arms.
   (c) It uses fewer components than the overhead camshaft valve train.
   (d) It uses more engine oil than the overhead camshaft valve train.
A: (b) It requires pushrods to move the rocker arms.
Feedback: In an overhead valve engine, pushrods connect to the rocker arms and push against them when the lifters push up on the pushrods.

Q: Where is most of the oil in an engine when it is first started?
   (a) The oil filter
   (b) The engine block
   (c) The oil pan
   (d) The oil passages
A: (c) The oil pan
Feedback: Before an engine is started, most of the engine oil is in the oil pan at the bottom of the engine.

Q: What does it mean when the oil pressure indicator light comes on?
   (a) The oil pressure is low
   (b) The oil level is low
   (c) The oil filter should be changed
   (d) Generator
A: (a) The oil pressure is low
Feedback: The oil pressure indicator light warns the driver that the engine is unable to maintain oil pressure.

Q: What is the purpose of the radiator?
   (a) It pulls in outside air to reduce the temperature of the coolant.
   (b) It transfers heat from the engine to the passenger compartment.
   (c) It restricts the flow of coolant until the engine reaches operating temperature.
   (d) It transfers heat from the coolant to the outside air.
A: (d) It transfers heat from the coolant to the outside air.
Feedback: The radiator transfers heat from the coolant to the outside air.
ADDITIONAL RESOURCES

National Institute for Automotive Service Excellence (ASE)
www.asecert.org

National Automotive Technicians Education Foundation (NATEF)
www.natef.org

Auto Repair Info
www.auto-repair-info.com

Automotive Service Association® (ASA)
www.asashop.org

Automotive Youth Educational Systems (AYES)
www.ayes.org

Concept Carz—Prototype Vehicles
www.conceptcarz.com

Do-It Yourself Network
(click on “Automotive Repair”)
www.diynet.com

AutoSite—Maintenance
Beyond the Basics—An Automotive Encyclopedia
www.autosite.com/garage/encyclop/tocdoc.asp

ALLDATA LLC
Leader in Automotive Information
www.alldata.com

MotorCareers®: Internet Career Center for the Automotive and Trucking World
www.motorcareers.com

Autotech USA
Career Networking for Automotive, Truck and Collision Repair Technicians
www.autotechsusa.com

U.S. Bureau of Labor Statistics (BLS)— Automotive Service Technicians and Mechanics
www.bls.gov/oco/ocos181.htm


ORGANIZATIONS

AERA—Engine Rebuilders Association
“Located in Buffalo Grove, Illinois, AERA is a not-for-profit trade association serving the engine rebuilder/remanufacturing industry, machine shops, equipment, and parts and services suppliers since 1922. We maintain this site to give you the latest possible information available through AERA.”
www.aera.org

SAE—The Society of Automotive Engineers
One-stop resource for technical information and expertise used in designing, building, maintaining, and operating self-propelled vehicles for use on land or sea, in air or space.
www.sae.org

ASA—Automotive Service Association
Since 1951, ASA has been the leading organization for owners and managers of automotive service businesses that strive to deliver excellence in service and repairs to consumers.
www.asashop.org

IATN—International Automotive Technicians’ Network
Largest network of automotive technicians in the world with 45,774 professional automotive technicians from 130 countries. Mission is "To promote the continued growth, success and image of the professional automotive technician by providing a forum for the exchange of
OTHER PRODUCTS

Automotive Engines, VHS/DVD, Meridian Education
At the heart of every automobile is the engine... this series of videos not only explains the engine’s basic operating principles, but provides clear instruction for its maintenance and repair. Using close-ups of actual working parts along with computer animation, this set of eight videos covers every major part of a gasoline-driven engine. Each video summarizes the operation and construction of related components as well as demonstrating many important techniques for troubleshooting problems and the best methods for repair. The videos also demonstrate how to inspect, organize, and measure engine parts, check for damage, and disassemble and reassemble an engine. They briefly cover some machine shop operations such as grinding valves and seats, checking guide wear, and checking head warpage.
The series includes: Cylinder Head Service; Engine Bottom End Construction; Engine Teardown, Cleaning, Inspection; Engine Front End Construction; Engine Fundamentals; Engine Reassembly; Engine Top-End Construction; Short Block Service.
Item no: 24751, www.meridianeducation.com, 1-800-727-5507

Automotive Maintenance and Safety, VHS/DVD, Meridian Education
Combines four safety videos in various subject areas to provide a comprehensive look at this important topic. The series includes: Auto Shop Safety; Automotive Measurements; Basic Car Care; Vehicle Maintenance.
Item no: 29064, www.meridianeducation.com, 1-800-727-5507

Automotive Technicians, VHS/DVD, Meridian Education
Sponsored by the National Technician Education Foundation, this program explores automobile repair and collision repair. NATEF works closely with Automotive Service Excellent (ASE), the nation’s only industry-wide certification program for automotive technicians. Technicians with a sound education have a choice of career avenues. Aside from fixing cars and trucks, they can become service managers, service engineers, automotive writers, or even auto technology teachers.
Item no: 24924, www.meridianeducation.com, 1-800-727-5507

Career Encounters: Automotive, VHS/DVD, Meridian Education
This three-part series provides a detailed look at the career of an ASE certified auto technician, an alternative fuels vehicle technician, and an auto parts specialist, outlining the training and personal skills needed to succeed in each.
The series includes: Alternative Fuels Vehicle Technician; Auto Parts Specialist; Automotive Technicians.

Electrical Components Part I: Resistors/Batteries/Switches, VHS/DVD, Meridian Education
Fixed resistors, variable resistors, ballast resistors, batteries, and various types of switches are explained in this program. Computer animation, component cutaways, and lab experi-
ments are used to demonstrate how these basic components function. This is an informative video that will strengthen your curriculum. It is ideal for classes in electricity-electronics, technology, auto mechanics, and other technical areas.
Item no: 25277, www.meridianeducation.com, 1-800-727-5507

*Electrical Components Part II: Capacitors/Fuses/Flashers/Coils*, VHS/DVD, Meridian Education
Capacitors, fuses, fuse links, circuit breakers, flashers, coils, and other devices are discussed in this training tape. Computer animation, component cutaways, and lab experiments are used to demonstrate how these basic components are constructed and how they operate. This is a must-see for all students of electricity-electronics, technology courses, auto mechanics, and many other subject areas that involve electricity and electronics.
Item no. 25276, www.meridianeducation.com, 1-800-727-5507

*How Your Car Works*, VHS/DVD, Meridian Education
As you cruise down the road, have you ever wondered what is going on inside your vehicle? How does your engine, transmission, and brake system work? What really happens when you turn the ignition key or press down on the gas pedal? This video will help you become a resident expert on how a car operates. It will give you enough of a technical vocabulary to communicate with your auto mechanic, to read auto enthusiast magazines, to "talk cars" with your friends, or to begin serious study of automotive technology. If you like cars, you will enjoy this very informative, entertaining program.
Item no. 25618, www.meridianeducation.com, 1-800-727-5507

*Multimedia Auto Shop Safety*, CD-ROM, Shopware
This multimedia CD-ROM uses video, animation and still photos to examine the topics of general shop safety, fire safety and prevention, first aid, and safe tool use for mechanics. The program seeks to foster that professionalism by describing the safe care and use of hand and power tools, wrenches, auto body tools, and measuring devices. (For Windows/Macintosh)

*Safety First: Auto Shop Safety*, VHS/DVD, Cambridge Educational
Shows the proper way to operate hydraulic jacks, lifts, and chain falls. Also covers the proper procedure for recharging batteries, disposing of old batteries, and how to handle battery acid and other corrosive materials. The best way to clean oil spills to prevent falls is discussed, along with preventing fires and how to contain a fire if one should occur. Provides a step-by-step procedure for pulling a car into a shop, and discusses the importance of proper ventilation to prevent asphyxiation. Also covers the safe way to remove the radiator cap on a vehicle that has overheated.