Section 1

Introduction to Automotive Technology

We are truly living in a "world of wheels." Every day, millions of people depend on their cars, trucks, vans, and sport-utility vehicles as their primary means of transportation. As a result, economic experts predict a strong demand for skilled automobile technicians and related professionals for the foreseeable future. You have chosen to study an area of employment that pays well and will require thousands of new graduates yearly.

Section 1 will introduce you to the "basics" of automotive technology. It contains information on automobile construction and operation, ASE certification, safety, tools, service information, electricity, and vehicle maintenance.

This section will give you the knowledge needed to secure an entry-level job. It will also lay the groundwork for later chapters, which provide in-depth coverage of automotive technology.

1 The Automobile

After studying this chapter, you will be able to:

- Identify and locate the most important parts of a vehicle.
- Describe the purpose of the fundamental automotive systems.
- Explain the interaction of automotive systems.
- Describe major automobile design variations.
- Comprehend later text chapters with a minimum amount of difficulty.
- Correctly answer ASE certification test questions that require a knowledge of the major parts and systems of a vehicle.

The term ***automobile*** is derived from the Greek word *autos,* which means self, and the French word *mobile,* which means moving. Today's "self-moving" vehicles are engineering marvels of safety and dependability. Over the last century, engineers and skilled workers the world over have used all facets of ***technology*** (the application of math, science, physics, and other subjects) to steadily give us a better means of transportation.

You are about to begin your study of the design, construction, service, maintenance, and repair of the modern automobile. This chapter provides a "quick look" at the major automotive systems. By knowing a little about each of these systems, you will be better prepared to learn the more detailed information presented later in this text.

Today, failure of one system can affect the operation of a seemingly unrelated system. This makes a thorough understanding of how the whole automobile works especially important.

Tech Tip!
Try to learn something new about automotive technology every day. In addition to studying this book and doing the hands-on activities, read automotive magazines, "surf" the Internet, and watch "motor-sport" television programs. This will help you become a better technician by increasing you knowledge daily.

Parts, Assemblies, and Systems

A ***part*** is the smallest removable item on a car. A part is not normally disassembled. The word ***component*** is frequently used when referring to an electrical or electronic part. For example, a spark plug is an ignition system component that ignites the fuel in the engine.

An ***assembly*** is a set of fitted parts designed to complete a function. For example, the engine is an assembly that converts fuel into useable power to move the vehicle. Technicians must sometimes take assemblies apart and put them back together during maintenance, service, and repair operations. See **Figure 1-1**.

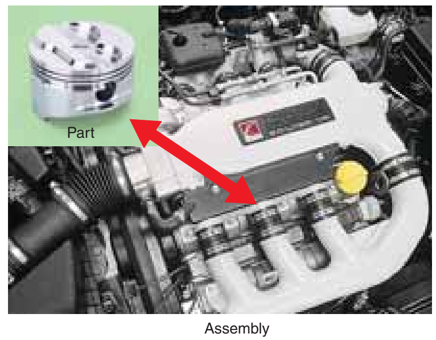


Figure 1-1. An assembly is a group of parts that work together to perform a function. For example, an engine is an assembly that contains pistons, which convert the fuel's heat energy into useable kinetic energy (motion). As you will learn, an engine has many other parts. (Saturn)

An automotive ***system*** is a group of related parts and assemblies that performs a specific function (job or task). For example, your vehicle's steering system contains the steering wheel, steering shaft, steering gears, linkage rods, and other parts. These parts allow you to control the direction of the wheels and tires for maneuvering (turning) your vehicle. Another example of a familiar system is the brake system. This system is a group of parts that performs a very important task—slowing and stopping your vehicle quickly and safely.

Figure 1-2 shows the major systems of a vehicle. Memorize the name and general location of each system. Automotive parts and systems can be organized into ten major categories:

- *Body and frame*—support and enclose the vehicle.
- *Engine*—provides dependable, efficient power for the vehicle.
- *Computer systems*—monitor and control various vehicle systems.
- *Fuel system*—provides a combustible air-fuel mixture to power the engine.
- *Electrical system*—generates and/or distributes the power needed to operate the vehicle's electrical and electronic components.
- *Cooling and lubrication systems*—prevent engine damage and wear by regulating engine operating temperature and reducing friction between internal engine parts.
- *Exhaust and emission control systems*—quiet engine noise and reduce toxic substances emitted by the vehicle.
- *Drive train systems*—transfer power from the engine to the drive wheels.
- *Suspension, steering, and brake systems*—support and control the vehicle.
- *Accessory and safety systems*—increase occupant comfort, safety, security, and convenience.

Frame, Body, and Chassis

The body and frame are the two largest sections of a motor vehicle. The ***frame*** is the strong metal structure that provides a mounting place for the other parts of the vehicle. The frame holds the engine, transmission, suspension, and other assemblies in position.

The ***body*** is a steel, aluminum, fiberglass, plastic, or composite skin forming the outside of the vehicle. The body is painted to give the vehicle an attractive appearance.

The term ***chassis*** is often used when referring to a vehicle's frame and everything mounted to it except the body—tires, wheels, engine, transmission, drive axle assembly, and frame. You can see the complex network of automotive parts and systems on the chassis shown in **Figure 1-3A**. When each part or system is "disassembled and studied" separately, you will find the inner workings of a motor vehicle easy to understand.

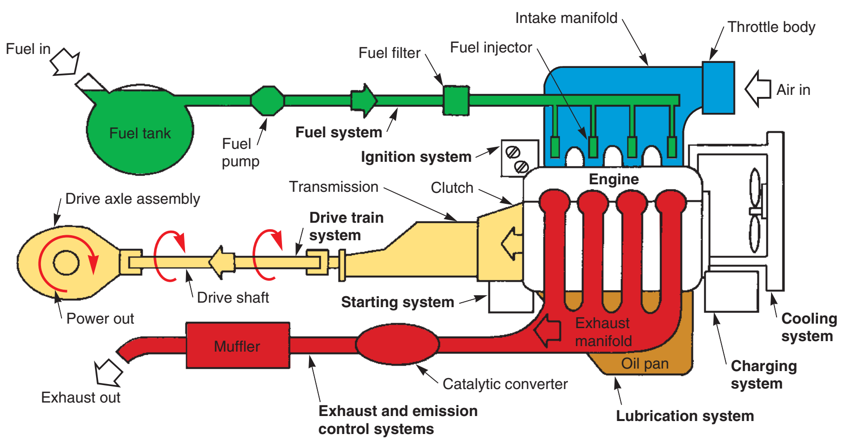


Figure 1-2. Note the general location of the major vehicle systems. Study the flow of fuel, air, exhaust, and power.

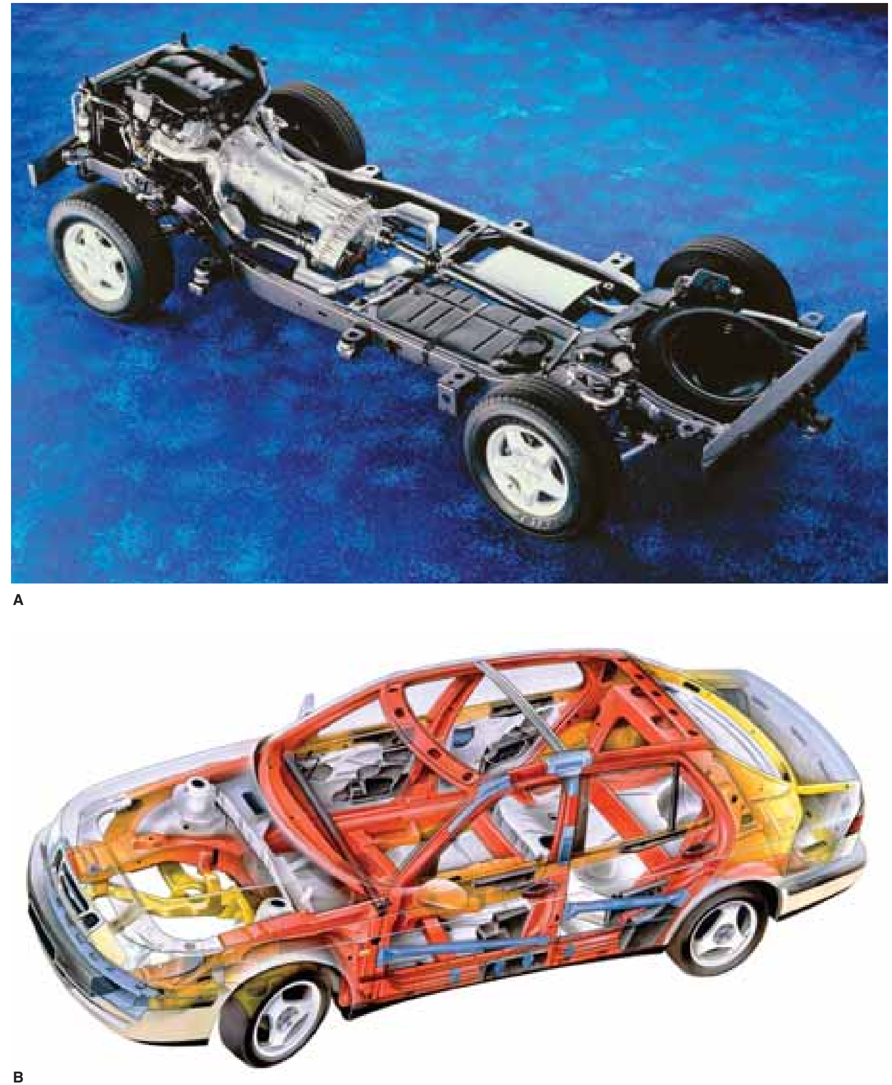


Figure 1-3. Compare body-over-frame and unibody construction. A—In body-over-frame construction, the chassis parts bolt to a strong perimeter frame. The body bolts to this thick steel frame. B—Unibody vehicles do not have a separate perimeter frame. Chassis components bolt directly to the unibody assembly. (DaimlerChrysler, Saab)

In ***body-over-frame construction***, the frame consists of thick steel members. The chassis parts and the body bolt to this frame. Also called full frame construction or perimeter frame construction, this design is heavy but strong. Body-over-frame construction is used on full-size cars, vans, pickup trucks, and sport-utility vehicles (SUVs). See **Figure 1-3A**.

With ***unibody construction***, sheet metal body panels are welded together to form the body and frame. Also called *space frame construction* or *unitized construction*, this is the most common type of configuration used to build small and medium passenger cars. Unibody construction reduces weight, improves fuel economy, and has a high strength-to-weight ratio. However, unibody vehicles are not as strong as those with body-over-frame construction. See **Figure 1-3B**.

Body Types

Automobiles are available in several body types, including the sedan, hardtop, convertible, hatchback, and station wagon. In addition, the minivan, the sport-utility vehicle, and the pickup truck have become increasingly popular.

A ***sedan*** is a car that has front and back seats and will carry four to six people. It has center body pillars, or "B" pillars, between the front and rear doors, **Figure 1-4A.** Both two-door and four-door sedans are available.

Figure 1-4. Note the various vehicle body styles. A—Sedan. B—Convertible. C—Hatchback. D—Station wagon. E—Minivan. F—Sport-utility vehicle. (DaimlerChrysler, Ford, Toyota)

A ***hardtop*** is similar to the sedan, but it has no "B" pillars. Hardtop vehicles are also available in both two- and four-door models.

A ***convertible*** has a vinyl or cloth top that can be raised and lowered. A convertible has no door pillars, and its strength is designed into the frame or floor pan. Although most convertibles are two-door models, **Figure 1-4B,** a few four-door convertibles have been produced.

A ***hatchback,*** or ***liftback,*** has a large rear door for easy access when hauling items. This style car is available in three- and five-door models, **Figure 1-4C.**

A ***station wagon*** has a long, straight roof that extends to the rear of the vehicle. Station wagons have large rear interior compartments and come in two- and four-door models. Some station wagons have space for up to nine passengers, see **Figure 1-4D.**

The ***minivan*** is similar to the station wagon, but it has a higher roofline for more headroom and cargo space. Most minivans are designed to carry seven passengers. See **Figure 1-4E.**

Sport-utility vehicles are often equipped with four-wheel-drive systems and have a tall body design. They provide the comfort of a passenger car, the interior space of a station wagon, and the durability of a truck, **Figure 1-4F.**

Common names for various automobile body parts are shown in **Figure 1-5.** Note that a vehicle's right and left sides are denoted as if you were sitting in the car looking forward.

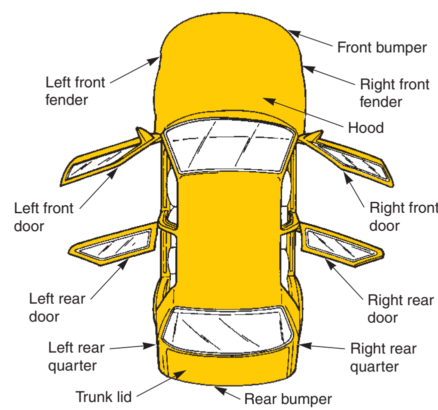


Figure 1-5. The right and left sides of a vehicle are denoted as if you were sitting forward inside passenger compartment.

Engine

The ***engine*** provides the energy to propel (move) the vehicle and operate the other systems. Most engines consume gasoline or diesel fuel. The fuel burns in the engine to produce heat. This heat causes gas expansion, creating pressure inside the engine. The pressure moves internal engine parts to produce power. See **Figure 1-6.**

The engine is usually located in the front portion of the body. Placing the heavy engine in this position makes the vehicle safer in the event of a head-on collision. In a few vehicles, the engine is mounted in the rear to improve handling. Refer to **Figure 1-7.**

Basic Engine Parts

The basic parts of a simplified one-cylinder engine are shown in **Figure 1-8.** Refer to this illustration as each part is introduced.

- The ***block*** is metal casting that holds all the other engine parts in place.
- The ***cylinder*** is a round hole bored (machined) in the block. It guides piston movement.
- The ***piston*** is a cylindrical component that transfers the energy of combustion (burning of air-fuel mixture) to the connecting rod.
- The ***rings*** seal the small gap around the sides of the piston. They keep combustion pressure and oil from leaking between the piston and the cylinder wall (cylinder surface).
- The ***connecting rod*** links the piston to the crankshaft.
- The ***crankshaft*** changes the *reciprocating* (up-and-down) motion of the piston and rod into useful *rotary* (spinning) motion.

Figure 1-6. An automotive engine commonly burns gasoline or diesel fuel to produce power. (Suzuki)

- The ***cylinder head*** covers and seals the top of the cylinder. It also holds the valves, rocker arms, and often, the camshaft.
- The ***combustion chamber*** is a small cavity (hollow area) between the top of the piston and the bottom of the cylinder head. The burning of the air-fuel mixture occurs in the combustion chamber.
- The ***valves*** open and close to control the flow of the air-fuel mixture into the combustion chamber and the exhaust gases out of the combustion chamber.
- The ***camshaft*** controls the opening of the valves.
- The ***valve springs*** keep the valves closed when they do not need to be open.
- The ***rocker arms*** transfer camshaft action to the valves.
- The ***lifters,*** or ***followers,*** ride on the camshaft and transfer motion to the other parts of the valve train.
- The ***flywheel*** helps keep the crankshaft turning smoothly. It also provides a large gear for the starting motor.

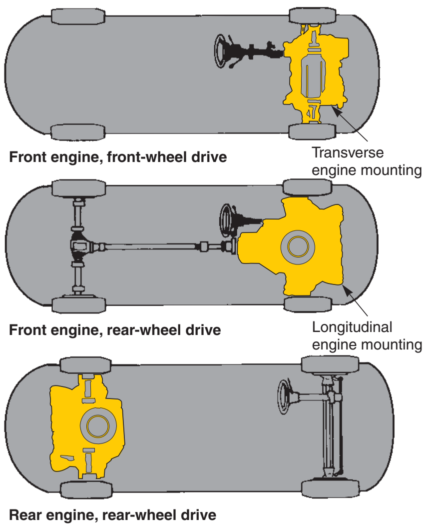


Figure 1-7. The engine can be located in the front or rear of the vehicle. (Dana Corp.)

Four-Stroke Cycle

Automobile engines normally use a ***four-stroke cycle.*** Four separate piston ***strokes*** (up or down movements) are needed to produce one ***cycle*** (complete series of events). The piston must slide down, up, down, and up again to complete one cycle.

As the four strokes are described below, study the simple drawings in **Figure 1-9.**

1. The ***intake stroke*** draws the air-fuel mixture into the engine's combustion chamber. The piston slides down while the intake valve is open and the exhaust valve is closed. This produces a vacuum (low-pressure area) in the cylinder. Atmospheric pressure (outside air pressure) can then force air and fuel into the combustion chamber.
2. The ***compression stroke*** prepares the air-fuel mixture for combustion. With both valves closed, the piston slides upward and compresses (squeezes) the trapped air-fuel mixture.

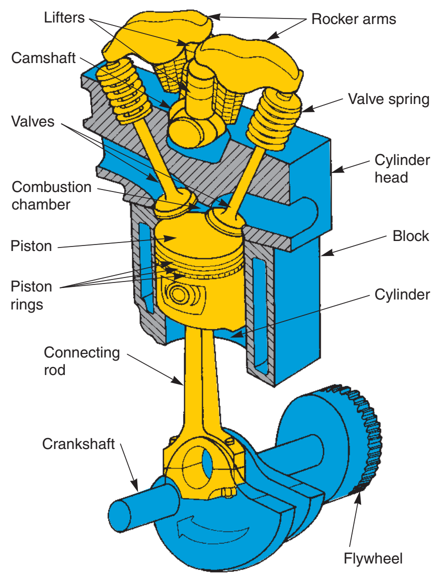
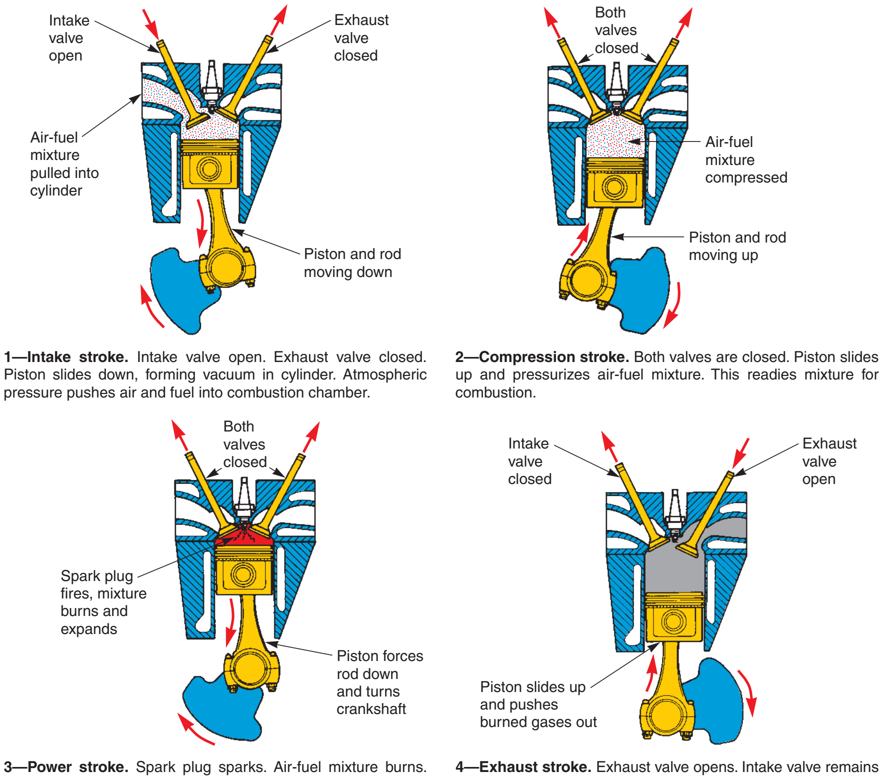


Figure 1-8. Memorize the basic parts of this one-cylinder engine.



1—Intake stroke. Intake valve open. Exhaust valve closed. Piston slides down, forming vacuum in cylinder. Atmospheric pressure pushes air and fuel into combustion chamber.

2—Compression stroke. Both valves are closed. Piston slides up and pressurizes air-fuel mixture. This readies mixture for combustion.

3—Power stroke. Spark plug sparks. Air-fuel mixture burns. High pressure forces piston down with tremendous force. Crankshaft rotates under power.

4—Exhaust stroke. Exhaust valve opens. Intake valve remains closed. Piston slides up, pushing burned gases out of cylinder. This prepares combustion chamber for another intake stroke.

Figure 1-9. A gasoline engine normally operates on a four-stroke cycle. Study the series of events.

3. The ***power stroke*** produces the energy to operate the engine. With both valves still closed, the spark plug arcs (sparks) and ignites the compressed air-fuel mixture. The burning fuel expands and develops pressure in the combustion chamber and on the top of the piston. This pushes the piston down with enough force to keep the crankshaft spinning until the next power stroke.
4. The ***exhaust stroke*** removes the burned gases from the combustion chamber. During this stroke, the piston slides up while the exhaust valve is open and the intake valve is closed. The burned fuel mixture is pushed out of the engine and into the exhaust system.

During engine operation, these four strokes are repeated over and over. With the help of the heavy flywheel, this action produces smooth, rotating power output at the engine crankshaft.

Obviously, other devices are needed to lubricate the engine parts, operate the spark plug, cool the engine, and provide the correct fuel mixture. These devices will be discussed shortly.

Automotive Engines

Unlike the basic one-cylinder engine just discussed, automotive engines are ***multi-cylinder engines,*** which means they have more than one piston and cylinder. Vehicles commonly have 4-, 6-, 8-, or 10-cylinder engines. The additional cylinders smooth engine operation because there is less time (degrees of crankshaft rotation) between power strokes. Additional cylinders also increase power output.

An actual automotive engine is pictured in **Figure 1-10.** Study the shape, location, and relationship of the major parts.

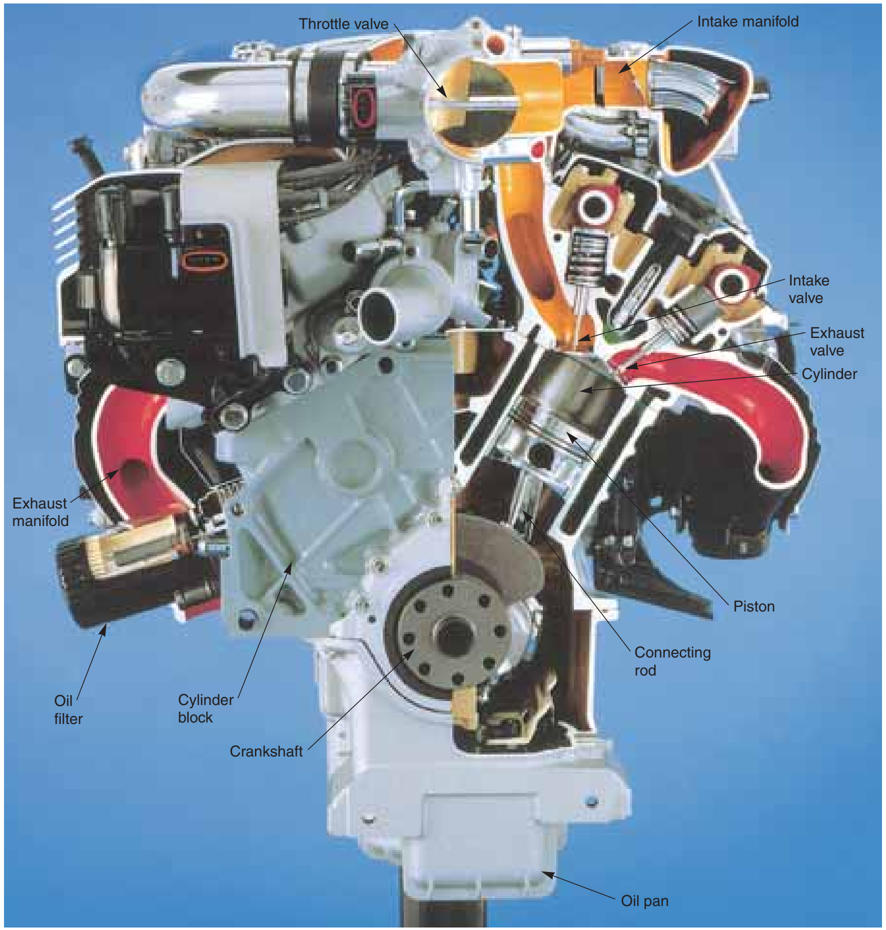


Figure 1-10. Automotive engines are multi-cylinder engines. Locate the major parts and visualize their operation. (Ford)

Computer System

The ***computer system*** uses electronic and electrical devices to monitor and control various systems in the vehicle, including the fuel, ignition, drive train, safety, and security systems. See **Figure 1-11.** The use of computer systems has improved vehicle efficiency and dependability. Additionally, most of these systems have self-diagnostic capabilities. There are three major parts of an automotive computer system:

- ***Sensors—***input devices that can produce or modify electrical signals with a change in a condition, such as motion, temperature, pressure, etc. The sensors are the "eyes, ears, and nose" of the computer system.
- ***Control module—***computer (electronic circuit) that uses signals from input devices (sensors) to control various output devices. The control module is the "brain" of the computer system.
- ***Actuators—***output devices, such as small electric motors, that can move parts when energized by the control module. The actuators serve as the "hands and arms" of the computer system.

A modern car can have several control modules and dozens of sensors and actuators. These components will be detailed throughout this book.

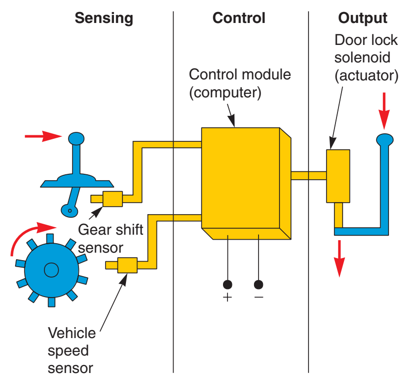


Figure 1-11. This computer-controlled lock system automatically locks the doors as soon as the vehicle starts moving. When the gear shift sensor and the vehicle speed sensor send the correct signals to the control module, the module energizes the solenoid (actuator). The solenoid then converts the electrical signal from the control module to a linear motion, locking the doors.

Tech Tip!
Learn all you can about electricity and electronics. Nearly every automotive system is now monitored or controlled by a computer. It is almost impossible to service any system of a car without handling some type of electric or electronic component. This book covers electronics in almost every chapter.

Fuel System

The ***fuel system*** must provide the correct mixture of air and fuel for efficient ***combustion*** (burning). This system must add the right amount of fuel to the air entering the cylinders. This ensures that a very ***volatile*** (burnable) mixture enters the combustion chambers.

The fuel system must also alter the ***air-fuel ratio*** (percentage of air and fuel) with changes in operating conditions (engine temperature, speed, load, and other variables).

There are three basic types of automotive fuel systems: gasoline injection systems, diesel injection systems, and carburetor systems. Look at the three illustrations in **Figure 1-12**.

Gasoline Injection System

Modern ***gasoline injection systems*** use a control module, sensors, and electrically operated ***fuel injectors*** (fuel valves) to meter fuel into the engine. This is the most common type of fuel system on gasoline, or spark ignition, engines. See **Figure 1-12A.**

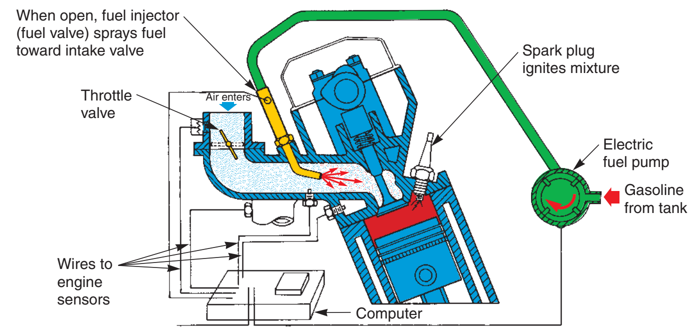
An electric ***fuel pump*** forces fuel from the fuel tank to the engine. The control module, reacting to electrical data it receives from the sensors, opens the injectors for the correct amount of time. Fuel sprays from the open injectors, mixing with the air entering the combustion chambers.

A ***throttle valve*** controls airflow, engine speed, and engine power. When the throttle valve is open for more engine power output, the computer holds the injectors open longer, allowing more fuel to spray out. When the throttle valve is closed, the computer opens the injectors for only a short period of time, reducing power output.

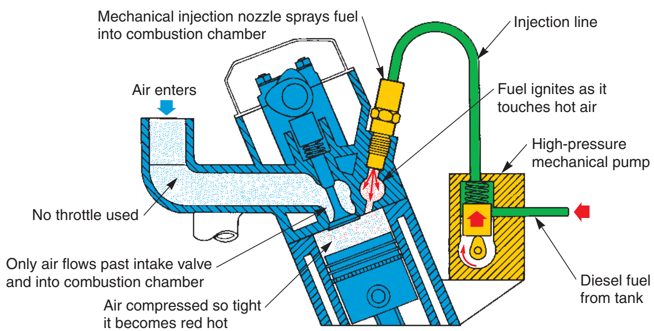
The throttle valve (air valve) is connected to the accelerator pedal. When the pedal is pressed, the throttle valve opens to increase engine power output.

Diesel Injection System

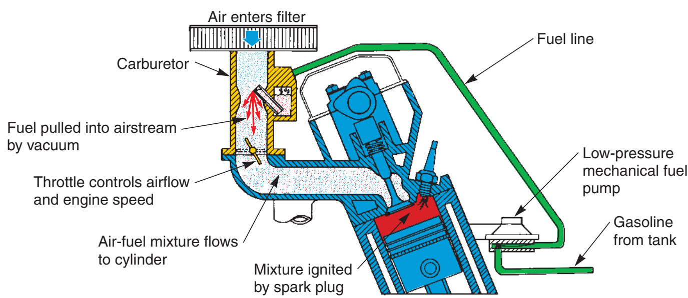
A ***diesel fuel system*** is primarily a mechanical system that forces diesel fuel (not gasoline) directly into the combustion chambers. Unlike the gasoline engine, the diesel engine does *not* use spark plugs to ignite the air-fuel mixture. Instead, it uses the extremely high



A—Gasoline injection system. Engine sensors feed information (electrical signals) to computer about engine conditions. Computer can then open injector for right amount of time. This maintains correct air-fuel ratio. Spark plug ignites fuel.



B—Diesel injection system. High-pressure mechanical pump sprays fuel directly into combustion chamber. Piston squeezes and heats air enough to ignite diesel fuel. Fuel begins to burn as soon as it touches heated air. Note that no throttle valve or spark plug is used. Amount of fuel injected into chamber controls diesel engine power and speed.



C—Carburetor fuel system. Fuel pump fills carburetor with fuel. When air flows through carburetor, fuel is pulled into engine in correct proportions. Throttle valve controls airflow and engine power output.

Figure 1-12. Note the three basic types of fuel systems. Compare differences.

pressure produced during the compression stroke to heat the air in the combustion chamber. The air is squeezed until it is hot enough to ignite the fuel. Refer to **Figure 1-12B.**

When the mechanical pump sprays the diesel fuel into a combustion chamber, the hot air in the chamber causes the fuel to begin to burn. The burning fuel expands and forces the piston down on the power stroke. Electronic devices are commonly used to monitor and help control the operation of today's diesel injection systems.

Carburetor Fuel System

The ***carburetor fuel system*** uses engine *vacuum* (suction) to draw fuel into the engine. The amount of airflow through the carburetor determines the amount of fuel used. This automatically maintains the correct air-fuel ratio. Refer to **Figure 1-12C.**

Either a mechanical or an electric fuel pump draws fuel out of the tank and delivers it to the carburetor. The engine's intake strokes form a vacuum inside the intake manifold and carburetor. This causes gasoline to be drawn from the carburetor and into the air entering the engine.

Electrical System

The vehicle's ***electrical system*** consists of several subsystems (smaller circuits): ignition system, starting system, charging system, and lighting system. Each subsystem is designed to perform a specific function, such as "fire" the spark plugs to ignite the engine's fuel mixture, rotate the crankshaft to start the engine, illuminate the highway for safe night driving, etc.

Ignition System

An ***ignition system*** is needed on gasoline engines to ignite the air-fuel mixture. It produces an extremely high voltage surge, which operates the ***spark plugs.*** A very hot electric arc jumps across the tip of each spark plug at the correct time. This causes the air-fuel mixture to burn, expand, and produce power. Study **Figure 1-13.**

With the ignition switch on and the engine running, the system uses sensors to monitor engine speed and other operating variables. Sensor signals are fed to the control module. The control module then modifies and ***amplifies*** (increases) these signals into on-off current pulses that

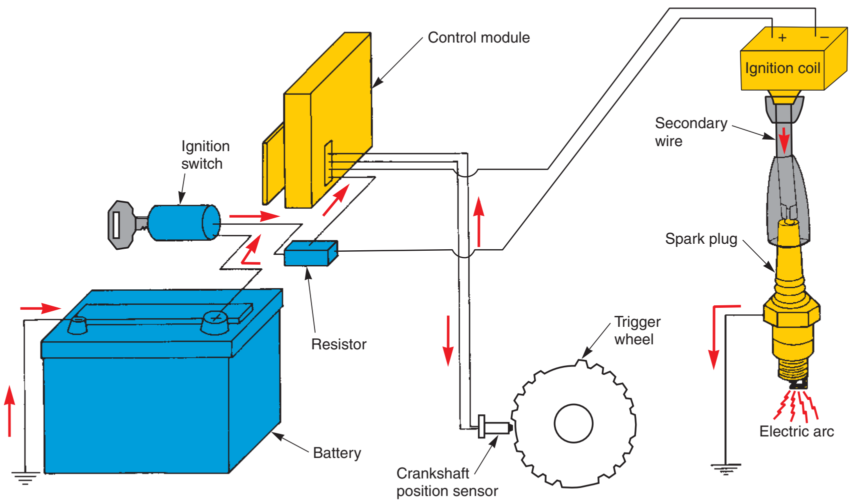


Figure 1-13. The ignition system is used on gasoline engines to start combustion. The spark plug must fire at the correct time during the compression stroke. A crankshaft position sensor or a distributor operates the ignition module. The module operates the ignition coil. The coil produces high voltage for the spark plugs.

trigger the ignition coil. When triggered, the ***ignition coil*** produces a high voltage output to "fire" the spark plugs. When the ignition key is turned off, the coil stops functioning and the spark-ignition engine stops running.

Starting System

The ***starting system*** has a powerful electric ***starting motor*** that rotates the engine crankshaft until the engine "fires" and runs on its own power. The major parts of the starting system are shown in **Figure 1-14A.**

A ***battery*** provides the electricity for the starting system. When the key is turned to the *start* position, current flows through the starting system circuit. The starting motor is energized, and the starting motor pinion gear engages a gear on the engine flywheel. This spins the crankshaft. As soon as the engine starts, the driver must shut off the starting system by releasing the ignition key.

Charging System

The ***charging system*** is needed to replace electrical energy drawn from the battery during starting system operation. To re-energize the battery, the charging system forces electric current back into the battery. The fundamental parts of the charging system are shown in **Figure 1-14B.** Study them!

When the engine is running, a ***drive belt*** spins the alternator pulley. The ***alternator*** (generator) can then produce electricity to recharge the battery and operate other electrical needs of the vehicle. A ***voltage regulator,*** usually built into the alternator, controls the voltage and current output of the alternator.

Lighting System

The ***lighting system*** consists of the components that operate a vehicle's interior and exterior lights (fuses, wires, switches, relays, etc.). The exact circuit and part configurations will vary from one model to another.

The *exterior lights* typically include the headlights, turn signals, brake lights, parking lights, backup lights, and side marker lights. The *interior lights* include the dome light, trunk light, instrument panel lights, and other courtesy lights.

Cooling and Lubrication Systems

The cooling and lubrication systems are designed to prevent engine damage and wear. They are important systems that prevent the engine from self-destructing.

The ***cooling system*** maintains a constant engine operating temperature. It removes excess combustion heat to prevent engine damage and also speeds engine warm-up. Look at **Figure 1-15.**

The ***water pump*** forces ***coolant*** (water and antifreeze solution) through the inside of the engine, hoses, and

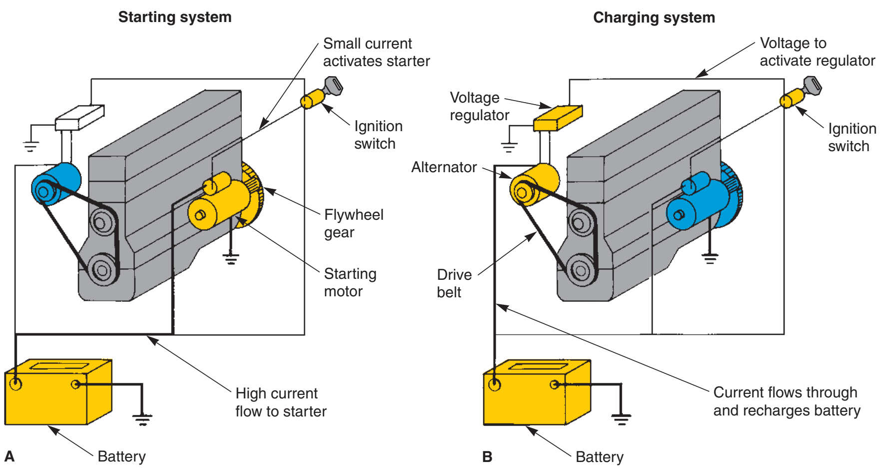


Figure 1-14. Note the basic actions and components of the starting and charging systems.

radiator. The coolant collects heat from the hot engine parts and carries it back to the radiator.

The ***radiator*** allows the coolant heat to transfer into the outside air. An ***engine fan*** draws cool air through the radiator. The ***thermostat*** controls coolant flow and engine temperature. It is usually located where the top radiator hose connects to the engine.

The ***lubrication system*** reduces friction and wear between internal engine parts by circulating filtered engine oil to high-friction points in the engine. The lubrication system also helps cool the engine by carrying heat away from internal engine parts.

Study the parts and operation of the lubrication system shown in **Figure 1-16.** Note how the ***oil pump*** pulls oil out of the pan and pushes it to various moving parts of the engine.

Exhaust and Emission Control Systems

The ***exhaust system*** quiets the noise produced during engine operation and routes engine exhaust gases to the rear of the vehicle body. **Figure 1-17** illustrates the basic parts of an exhaust system. Trace the flow of exhaust gases from the engine exhaust manifold to the tailpipe. Learn the names of the parts.

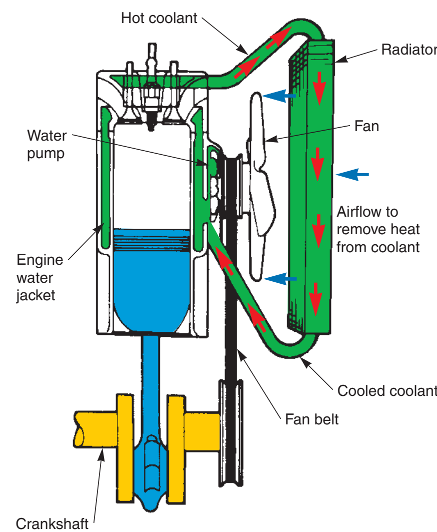


Figure 1-15. The cooling system must protect the engine from the heat of combustion. Combustion heat could melt and ruin engine parts. The system must also speed warm-up and maintain a constant operating temperature. Study the part names.

Various ***emission control systems*** are used to reduce the amount of *toxic* (poisonous) substances produced by an engine. Some systems prevent fuel vapors from entering the *atmosphere* (air surrounding the earth). Other emission control systems remove unburned and partially burned fuel from the engine exhaust. Later chapters cover these systems in detail.

Drive Train Systems

The ***drive train*** transfers turning force from the engine crankshaft to the drive wheels. Drive train configurations vary, depending on vehicle design. See **Figure 1-18.**

The drive train parts commonly found on a front-engine, rear-wheel-drive vehicle include the clutch, transmission, drive shaft, and rear axle assembly. The drive train parts used on most front-engine, front-wheel-drive vehicles include the clutch, transaxle, and drive axles. Refer to **Figure 1-18** as these components and assemblies are discussed.

Clutch

The ***clutch*** allows the driver to engage or disengage the engine and manual transmission or transaxle. When the clutch pedal is in the released position, the clutch locks the engine flywheel and the transmission input shaft together. This causes engine power to rotate the transmission gears and other parts of the drive train to propel the vehicle. When the driver presses the clutch pedal, the clutch disengages power flow and the engine no longer turns the transmission input shaft and gears.

Transmission

The ***transmission*** uses various gear combinations, or ratios, to multiply engine speed and torque to accommodate driving conditions. Low gear ratios allow the vehicle to accelerate quickly. High gear ratios permit lower engine speed, providing good gas mileage.

A ***manual transmission*** lets the driver change gear ratios to better accommodate driving conditions, **Figure 1-19.** An ***automatic transmission,*** on the other hand, does not have to be shifted by the driver. It uses an internal hydraulic system and, in most cases, electronic controls to shift gears. The input shaft of an automatic transmission is connected to the engine crankshaft through a ***torque converter*** (fluid coupling) instead of a clutch. The elementary parts of an automatic transmission are pictured in **Figure 1-20.**

Drive Shaft

The ***drive shaft,*** or propeller shaft, transfers power from the transmission to the rear axle assembly. Look at

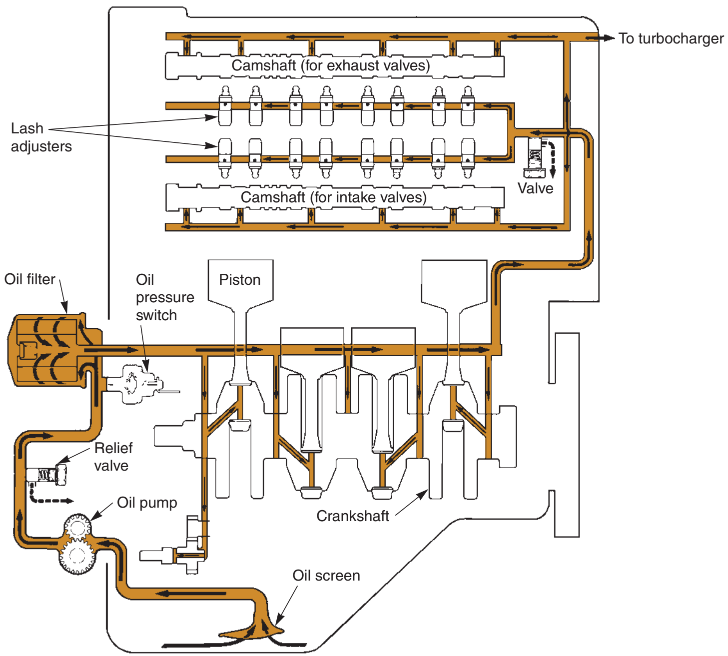


Figure 1-16. The lubrication system uses oil to reduce friction and wear. The pump forces oil to high-friction points.

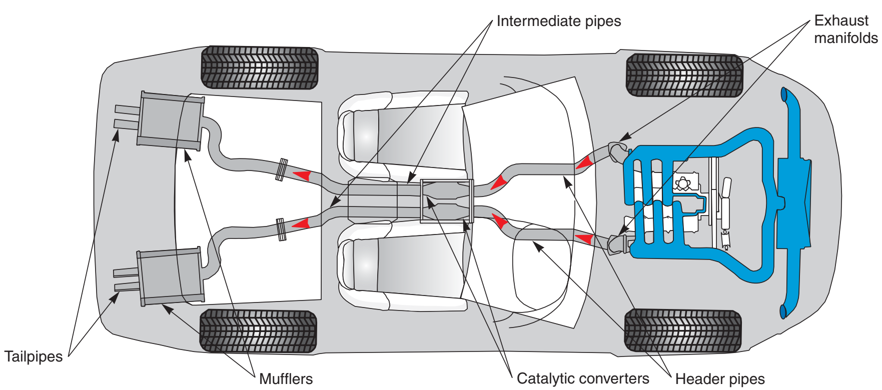


Figure 1-17. The exhaust system carries burned gases to the rear of the vehicle. It also reduces engine noise. (Nissan)

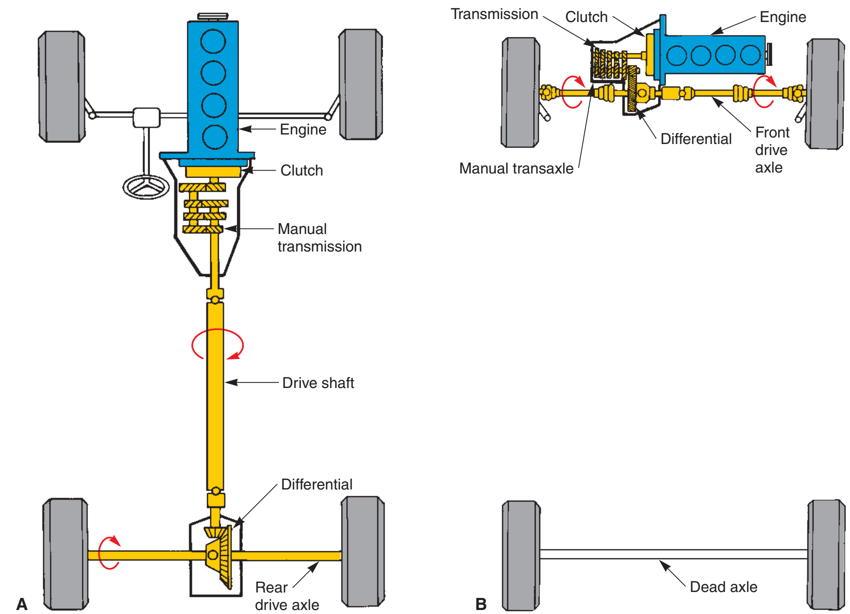


Figure 1-18. The drive train transfers engine power to the drive wheels. Study the differences between the two common types of drive trains. A—Front-engine, rear-wheel-drive vehicle. B— Front-engine, front-wheel-drive vehicle.

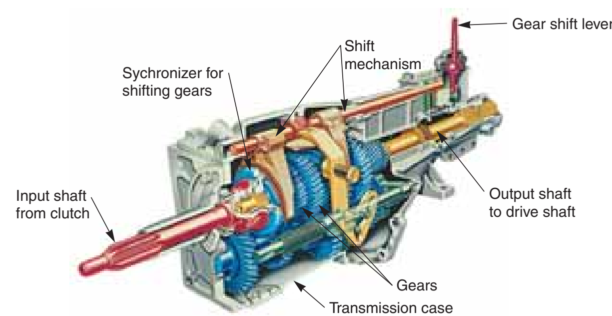


Figure 1-19. A manual transmission uses gears and shafts to achieve various gear ratios. The speed of the output shaft compared to the speed of the input shaft varies in each gear position. This allows the driver to change the amount of torque going to the drive wheels. In lower gears, the car accelerates quickly. When in high gear, engine speed drops while vehicle speed stays high for good fuel economy. (Ford)

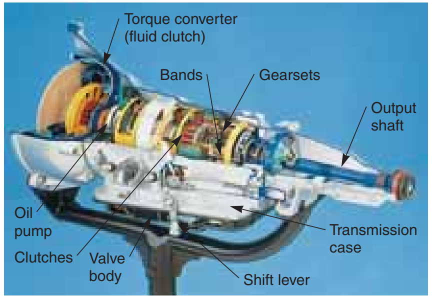


Figure 1-20. An automatic transmission serves the same function as a manual transmission. However, it uses a hydraulic pressure system to shift gears. (Ford)

Figure 1-21. It is a hollow metal tube with two or more universal (swivel) joints. The universal joints allow the rear suspension to move up and down without damaging the drive shaft.

Rear Axle Assembly

The ***rear axle assembly*** contains a differential and two axles. The ***differential*** is a set of gears and shafts that transmits power from the drive shaft to the axles. The ***axles*** are steel shafts that connect the differential and drive wheels, **Figure 1-21.**

Transaxle

The ***transaxle*** consists of a transmission and a differential in a single housing. Although a few rear-wheel-drive vehicles are equipped with transaxles, they are most commonly used with front-wheel-drive vehicles, **Figure 1-22.** Both manual and automatic transaxles are available. The internal parts of a modern transaxle assembly are illustrated in **Figure 1-23**.

Front Drive Axles

The ***front drive axles*** connect the transaxle differential to the hubs and wheels of the vehicle. These axles are equipped with constant-velocity joints, which allow the front wheels to be turned to the left or right and to move up and down.

Suspension, Steering, and Brake Systems

The suspension, steering, and brake systems are the movable parts of the chassis. They bolt or anchor to the frame and provide important functions that will be explained in the following sections.

Suspension System

The ***suspension system*** allows the vehicle's wheels and tires to move up and down with little effect on body movement. This makes the vehicle's ride smooth and safe. The suspension system also prevents excessive body lean when turning corners quickly.

Figure 1-21. The drive shaft sends power to the rear axle assembly. The rear axle assembly contains the differential and two axles that turn the rear drive wheels. (Lexus)

As you can see in **Figure 1-24,** various springs, bars, swivel joints, and arms make up the suspension system.

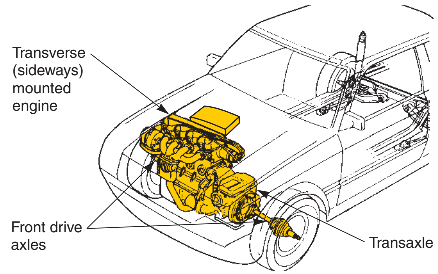


Figure 1-22. Front-wheel-drive vehicles do not have a drive shaft or a rear drive axle assembly. The complete drive train is in the front of the vehicle. (Ford)

Steering System

The ***steering system*** allows the driver to control vehicle direction by turning the wheels right or left. It uses a series of gears, swivel joints, and rods to do this. Study the names of the parts in **Figure 1-24.**

Brake System

The ***brake system*** produces friction to slow or stop the vehicle. When the driver presses the brake pedal, fluid pressure actuates a brake mechanism at each wheel. These mechanisms force friction material (brake pads or shoes) against metal discs or drums to slow wheel rotation. **Figure 1-25** shows the fundamental parts of a brake system.

Accessory and Safety Systems

Common ***accessory systems*** include the air conditioner, sound system, power seats, power windows, and rear window defogger. Common ***safety systems*** include seat belts, air bags, and security systems. See **Figure 1-26.**

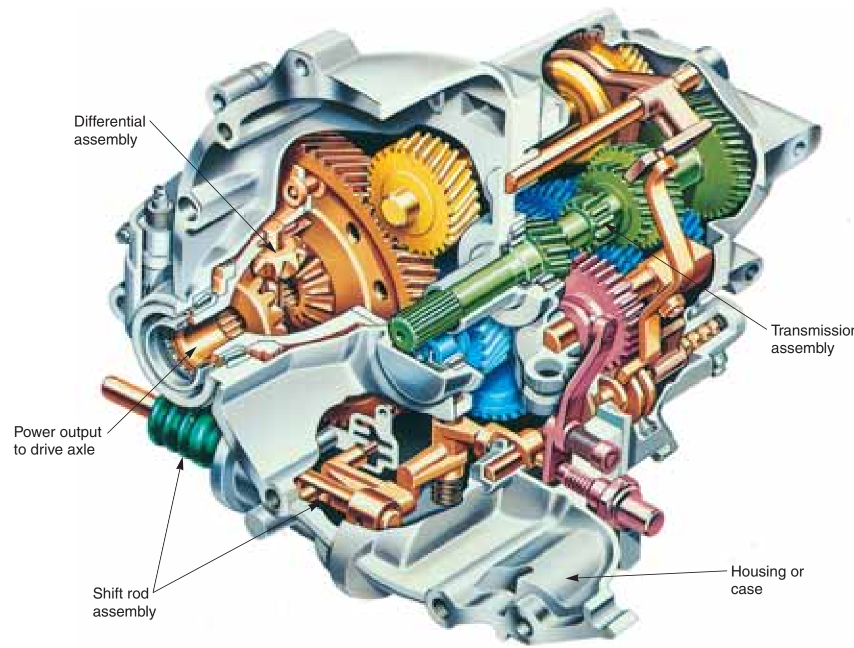


Figure 1-23. A transaxle contains a transmission and a differential in one housing. (Ford)

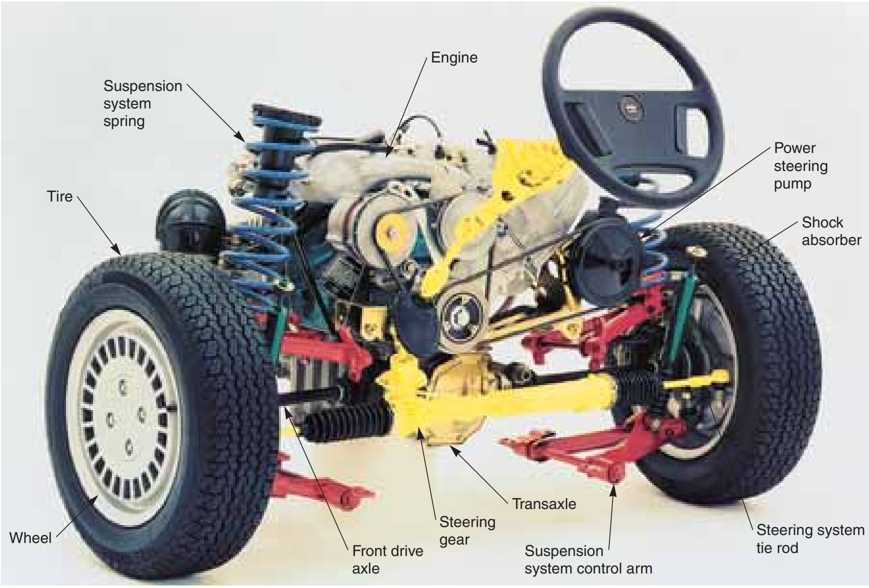


Figure 1-24. The suspension and steering systems mount on the frame. Study the part names. (Saab-Scania)

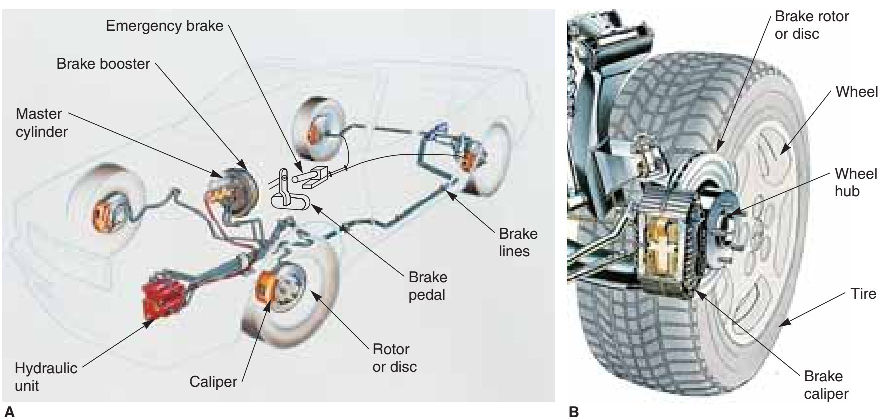


Figure 1-25. When the brake pedal is pressed, pressure is placed on a confined fluid. The fluid pressure transfers through the system to operate the brakes. An emergency brake is a mechanical system that applies the rear wheel brakes. A—Complete system. B—Close-up. (Cadillac, Nissan)

Highway History

Early automobile manufacturers originated in various ways. In many instances, they evolved from bicycle makers, carriage and wagon makers, and other types of industry. Early motorcars were similar to horse-drawn buggies, but they were equipped with noisy gasoline-powered engines, steam engines, or electric motors and batteries. A single lever called a tiller was used to steer the vehicle and another lever was used to apply the brakes.

Summary

- The body and frame support, stop, and enclose the vehicle.
- The engine provides dependable, efficient power for the vehicle.
- The intake stroke draws the air-fuel mixture into the engine combustion chamber.
- The compression stroke prepares the fuel mixture for combustion.
- The power stroke produces the energy to operate the engine.
- The exhaust stroke must remove the burned gases from the engine cylinders.
- The computer system uses electronic and electrical devices to monitor and control various systems in the vehicle.
- The fuel system provides the correct mixture of air and fuel for efficient combustion.
- Electrical systems operate the electrical-electronic devices.
- The cooling system maintains a constant engine operating temperature.
- The lubrication system reduces friction between internal engine parts.
- Emission control systems reduce air pollution produced by the vehicle.
- Drive train systems transfer turning force from the engine crankshaft to the drive wheels.
- Suspension, steering, and brake systems support and control the vehicle.
- Accessory and safety systems increase passenger comfort, safety, security and convenience.

Figure 1-26. Various safety systems are used on modern vehicles to protect both the driver and the passengers. This vehicle is equipped with both front and side-impact air bags. (Audi)

Important Terms

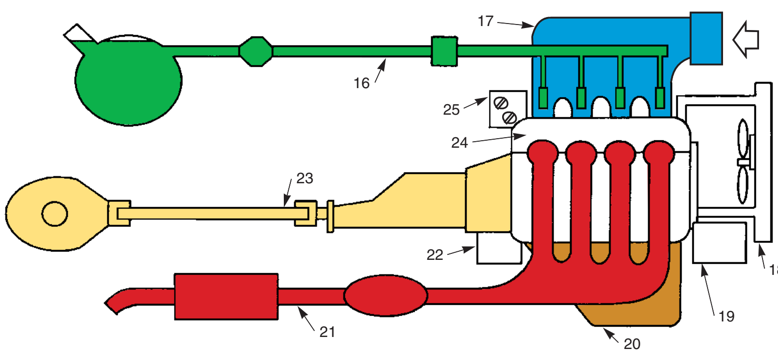
Automobile
Technology
Part
Component
Assembly
System
Frame
Body
Chassis
Exhaust stroke
Multi-cylinder engines
Computer system
Fuel system
Air-fuel ratio
Gasoline injection systems
Diesel fuel system
Carburetor fuel system
Ignition system
Starting system
Charging system
Body-over-frame construction
Unibody construction
Engine
Four-stroke cycle
Intake stroke
Compression stroke
Power stroke
Lighting System
Cooling system
Lubrication system
Exhaust system
Emission control systems
Drive train
Suspension system
Steering system
Brake system
Accessory systems
Safety systems

Review Questions—Chapter 1

Please do not write in this text. Place your answers on a separate sheet of paper.

1. What is an automotive system?
2. Automotive parts and systems can be grouped into ten categories. Name them.
3. Which of the following is *not* part of an engine?
   (A) Block.
   (B) Piston.
   (C) Muffler.
   (D) Crankshaft.
4. Explain the engine's four-stroke cycle.
5. Most car engines are multi-cylinder engines. True or False?
6. List and describe the three common types of fuel systems.
7. A diesel engine does *not* use spark plugs. True or False?
8. The car's electrical system consists of the:
   (A) ignition, starting, lubrication, and lighting systems.
   (B) ignition, charging, lighting, and hydraulic systems.
   (C) lighting, charging, starting, and ignition systems.
   (D) None of the above.
9. The _____ _____ system reduces the amount of toxic substances released by the vehicle.
10. What is the difference between a manual transmission and an automatic transmission?
11. A one-piece drive shaft rotates the drive wheels on most front-wheel drive cars. True or False?
12. A rear axle assembly contains two _____ and a(n) _____.
13. Explain the term "transaxle."
14. The suspension system mounts the car's wheels solidly on the frame. True or False?
15. List four accessory systems.

16–25. Identify the parts and systems illustrated below. Write the numbers 16–25 on your paper. Then write the correct letter and words next to each number.



Can you identify the following parts and systems? (A) Starting system. (B) Charging system. (C) Drive train. (D) Fuel system. (E) Cooling system. (F) Engine. (G) Ignition system. (H) Lubrication system. (I) Exhaust system. (J) Intake manifold.

ASE-Type Questions

1. A vehicle is brought into the shop with a slipping clutch. Technician A says that the clutch is part of the drive train system. Technician B says that the clutch is part of the suspension system. Who is correct?
   (A) A only.
   (B) B only.
   (C) Both A and B.
   (D) Neither A nor B.
2. When the internal body structure of a vehicle is used as its frame, it is called:
   (A) unibody construction.
   (B) body-frame construction.
   (C) integral construction.
   (D) body-over-frame construction.
3. The _____ controls the opening of engine's valves.
   (A) camshaft
   (B) crankshaft
   (C) valve springs
   (D) combustion chamber
4. Which piston stroke of the four-stroke cycle prepares the fuel mixture for combustion?
   (A) Power.
   (B) Intake.
   (C) Exhaust.
   (D) Compression.
5. All of the following are major components in the computer system except:
   (A) regulators.
   (B) sensors.
   (C) actuators.
   (D) computer.
6. Each of the following is a basic type of automotive fuel system except:
   (A) carburetor.
   (B) auto injection.
   (C) diesel injection.
   (D) gasoline injection.
7. Tests show that an engine is not getting spark at the spark plugs. Technician A says it could be due to the diesel injection system. Technician B says to test the ignition coil. Who is right?
   (A) A only.
   (B) B only.
   (C) Both A and B.
   (D) Neither A nor B.
8. A car with a dead battery is brought into the shop. Technician A says to check the output of the alternator. Technician B says to check the condition of the spark plugs. Who is right?
   (A) A only.
   (B) B only.
   (C) Both A and B.
   (D) Neither A nor B.
9. Since an automatic transmission does not have to be shifted by hand, Technician A believes it uses a hydraulic system to shift gears. Technician B believes it uses oil pressure to shift gears. Who is right?
   (A) A only.
   (B) B only.
   (C) Both A and B.
   (D) Neither A nor B.
10. A transaxle case contains both the:
   (A) carburetor and drive shaft.
   (B) transmission and differential.
   (C) multi-cylinder engine and clutch.
   (D) suspension components and brakes.

Activities—Chapter 1

1. Draw an automotive engine and drive train and label the parts. Then describe how the power is transferred from the engine to the drive wheels.
2. Using illustrations from the text, produce overhead transparencies of the four-stroke cycle and demonstrate the cycle to your class.
3. Arrange a field trip to tour an automobile assembly plant or to an auto shop.