17.1
Maintaining the Power Systems

Objectives
1. Identify the warning signs for needed repairs for the power and drive systems, ignition and electrical systems, lubrication and cooling systems, and fuel and exhaust systems.
2. Describe the steps to follow to start a vehicle that has a dead battery.

Your vehicle consists of many systems. Knowing about the different systems and the care they need can help you recognize and handle problems if they occur. Your owner's manual provides valuable information about how to maintain your vehicle and its various systems.

Power and Drive Systems

A vehicle's engine needs fuel to burn to create the power to move. The power generated from the **powerplant,** also known as the vehicle's engine or motor, is transmitted to a drive system that operates the front wheels, rear wheels, or all wheels in some vehicles. The powerplant is the source of energy that maintains a vehicle's movement.

New vehicles are powered by different types of internal combustion engines and a variety of electric motors or engine combinations. Selection of powerplant for a particular vehicle is based on its weight, usage, and government regulations.

Different drive-train systems are used for different vehicles. Some vehicles are rear-wheel drive, some front-wheel drive, and others all-wheel drive. The picture shows a front-wheel drive system.

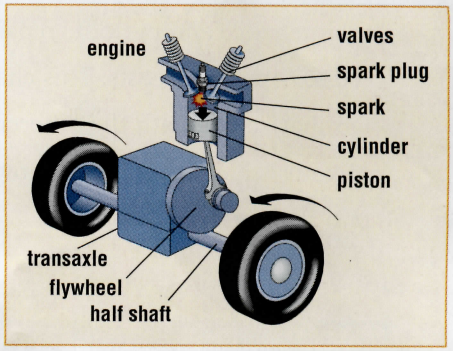
Depending on the type of vehicle, the drive train has different components including

- powerplant (engine or motor)
- transmission
- clutch (in a stickshift)
- drive shaft or half shafts
- differential
- transaxle
- drive axles
- universal, or constant velocity joints

A vehicle's **transmission** houses different gears. The gears of the transmission enable the engine to deliver power to the drive wheels. Lower gears are for power and let the engine turn faster. Higher gears are for greater speed and let the engine turn more slowly and efficiently.

The **drive shaft** is a long metal tube in rear-wheel drive vehicles. The drive shaft carries power from the transmission to the **differential** in the rear of the vehicle. The differential has gears that allow one wheel to turn more slowly than the other when turning a corner.

In front-wheel drive vehicles, power is carried to the front wheels by two half shafts. A **transaxle** is



Transmitting power in a front-wheel drive vehicle

located between the two half shafts and replaces the transmission and differential.

Check your automatic transmission or transaxle fluid once a month. Jerky shifting, slipping in and out of gears while driving, or pauses before the vehicle starts to move are signs of a low transmission fluid level. Your owner's manual explains how to check the fluid level.

Ignition and Electrical Systems

The ignition system sets off combustion in your engine's cylinders. The electrical system is involved in the ignition process and also provides the electrical power needed to operate your vehicle's lights, controls, and accessories.

Alternator

When you turn your key in the ignition, an electrical current sent from the battery to the electric starter turns the engine. Once the engine is running, the **alternator** generates an electrical current that recharges the battery. A belt drives the alternator. Current from the battery continues to power the ignition system. This system delivers energy to each spark plug at the proper time to ignite the air–fuel mixture in each cylinder.

If the alternator light comes on while you are driving, or the battery gauge displays a strong discharge, the alternator is not working properly. It is not generating electricity. The problem could be as simple as a broken or loose belt, or as complicated as an internal electrical problem.

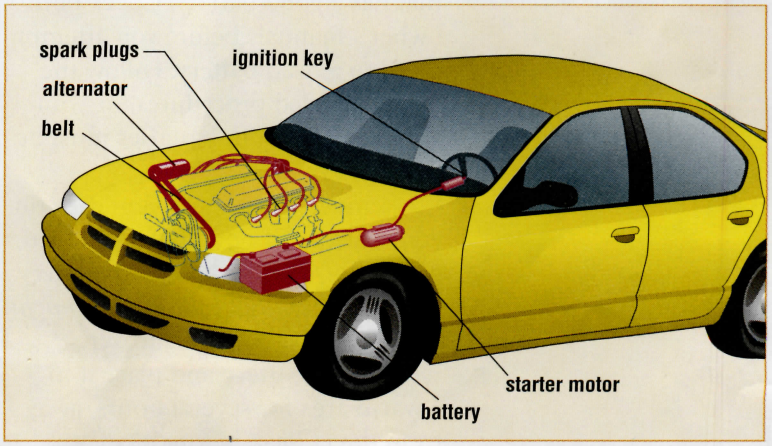
Battery

A vehicle's starter, lights, computer-assisted controls, and other electrical accessories depend on the electrical power stored in the battery.

Extreme cold or hot weather makes starting your vehicle difficult. A battery has less power when it is cold or overheated. Keep your battery charged to avoid failure. If the engine turns over very slowly when you try to start your vehicle, have the battery charged or replaced.

Keep battery cables tight and free of corrosion, especially where the terminals connect to the battery. Most batteries in today's vehicles are sealed and do not need to have their fluid levels checked. Read your owner's manual for maintenance information.

Always wear eye protection and gloves when working with, or around, a battery. A battery releases hydrogen gas, which is very explosive. Never expose a battery to an open flame or electrical spark. Never let



Ignition and electrical system

DRIVE RIGHT

DID YOU KNOW?

COMPUTERIZED SYSTEMS Many of today's vehicles are equipped with computerized engine-management systems. These systems control a vehicle's fuel, ignition, and emission systems. If a warning light comes on indicating your engine needs service, take it to a qualified technician who can service a computerized system.

battery fluid touch your eyes, skin, or clothing. The fluid is a strong acid that can cause severe injury.

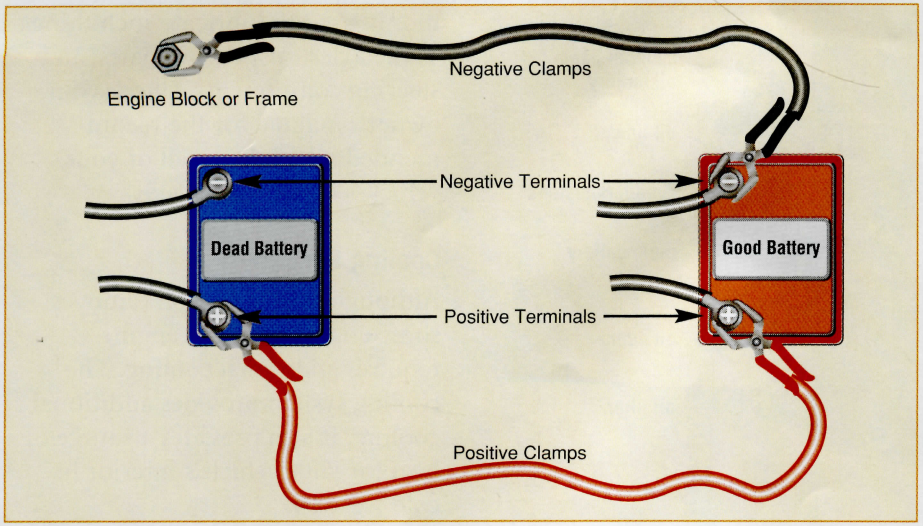
Starting a Vehicle That Has a Dead Battery

If you turn the ignition key while in PARK or NEUTRAL and the starter makes no sound, it usually indicates a dead battery or bad battery connection. You may be able to jump-start your vehicle by using a jumper cable connected to another vehicle that has a good battery. Check both owner's manuals before you attempt to jump a dead battery. Follow the recommended procedures for your vehicle. *Note:* Both batteries must be the same voltage.

Remove any battery vent caps on your battery (if not a self-contained battery). *Do not jump a dead battery that has frozen cells; the battery might explode.* If the battery is frozen, remove the battery and place it in a warm area for several hours, away from direct heat, before trying to jump-start it.

Follow these steps when making a jumper cable connection:

1. Bring the two vehicles close together, but not touching. The jumper cables need to be able to reach both batteries and engines.
2. Turn off the engine of the vehicle with the good battery and all accessories on both vehicles. Shift the gears of each vehicle into NEUTRAL or PARK. Set the parking brakes.
3. Each battery has two terminals or posts. Each post should be marked with a plus (+) or minus (–) sign, or POS or NEG.
4. Securely clamp one end of the positive jumper cable (marked + or red) to the positive terminal of the good battery. Clamp the other end of the same cable to the positive terminal of the dead battery.
5. Clamp one end of the negative cable (marked − or black) to the negative terminal on the vehicle with the good battery. Note: Some owner's manuals may require the connection be to a negative ground somewhere on the engine away from moving parts.
6. Clamp the other end of the negative cable to a negative ground on the vehicle with the dead battery. A negative ground could be a large unpainted piece of metal away from moving engine parts and the battery. *Do not clamp the negative cable to the bad battery's negative post.*
7. Start the vehicle that has the good battery first. Let the vehicle idle for a few minutes. Then start the



Jumper cable connections for jump-starting a vehicle

vehicle with the dead battery. Keep the vehicle with the dead battery running, but only at idle, until the jumper cables are removed.

8. Remove the cables in the opposite order from which they were attached. Store them in the trunk for future use.
9. Replace any vent caps. Throw away any cloth used to wipe the battery parts because the cloth may have acid on it.

Lights

Your lights not only help you see, but also help others see you. Defective lights and bulbs need to be replaced immediately. Check your headlights, taillights, backup lights, and turn signals often.

If a turn signal indicator on your instrument panel does not flash, but remains on, it is likely that the turn signal light is burnt out. Determine which signal light is out and replace it. Check your owner's manual for specific types of bulbs and lights for your vehicle.

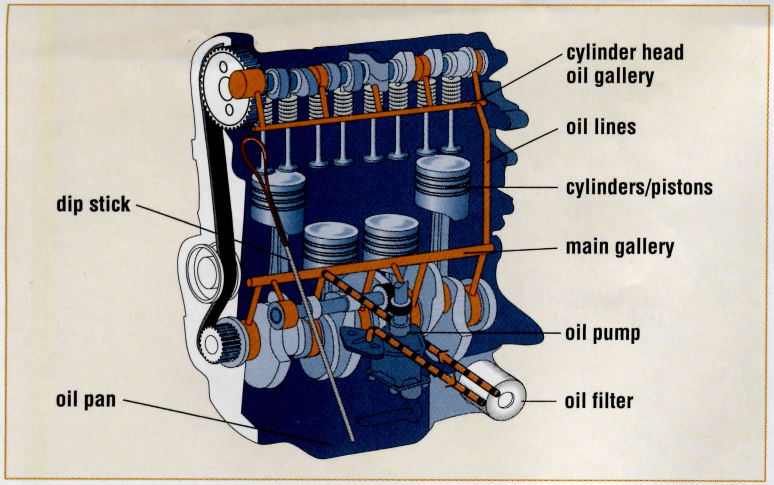
Lubrication and Cooling Systems

Lubrication is the use of oil, grease, or other substances to reduce damage to moving parts from heat caused by friction. *Cooling* is a process of reducing heat that builds up in a vehicle's engine or transmission. Excessive heat can destroy the engine and other moving parts of the vehicle. Proper lubrication and cooling keeps the systems operating efficiently.

Lubrication System

Lubricants, such as oil, help the engine operate efficiently by reducing friction, carrying away engine heat, and cleansing engine parts.

The **oil pump** forces oil from the oil pan at the bottom of the



Lubrication system

engine through the oil filter. From the filter, the oil flows through oil lines to the engine's moving parts. Oil is returned to the oil pan, and the cycle is repeated.

All vehicles need to have the oil changed, either after a specific number of miles or months. Oil filters are typically replaced at the same time. If you make a lot of short trips, you may need to have your oil and filter changed more often than recommended.

If the oil-pressure warning light comes on while you are driving, it indicates oil is not going through your engine quickly enough to lubricate it. Pull over to the side of the road when it is safe to do so. Turn off your engine and wait a while before checking the oil level. If your oil level is not the problem, your vehicle needs service right away. Low oil pressure can damage an engine very quickly.

Your vehicle also needs to be greased periodically. Grease is commonly used to lubricate such things as the axles, suspension parts, and steering components. Check your owner's manual for the recommended schedule for all of your vehicle's lubrication needs.

Cooling System

Although lubricating oil removes some engine heat, the engine requires additional cooling. The cooling system provides additional cooling. It also provides a source of heat for your vehicle's interior in cold weather.

The cooling system includes a fan, fan belt or electric motor, radiator, water pump, coolant recovery (or surge) tank, thermostat, and hoses that connect the radiator to the engine. The **radiator** holds and cools the coolant, a mixture of water and antifreeze. The owner's manual indicates the correct mixture to use in your vehicle.

The **water pump** draws coolant from the radiator and forces it through the engine's cooling passages. The fan draws air through the radiator and helps cool the coolant.

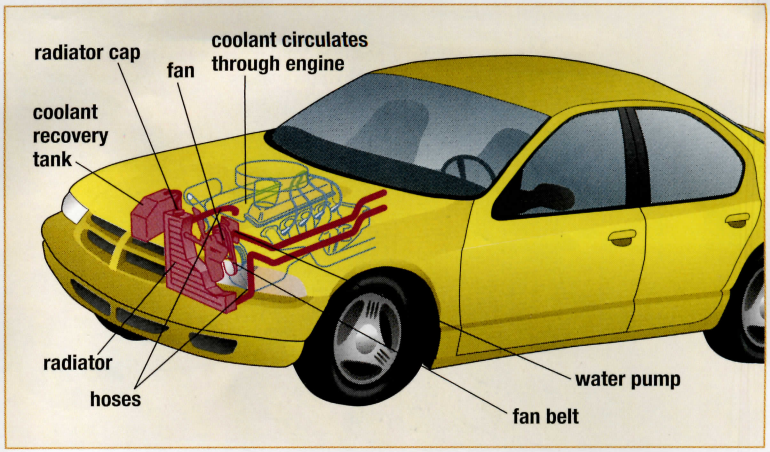
The **thermostat** opens and shuts to control the flow of coolant to the radiator. When the temperature in the system rises to the correct level, the thermostat opens to let coolant flow to the radiator and maintain a stable temperature.

Overheating can damage your engine as a result of a low coolant level, blocked radiator airflow, frozen coolant in the system, or a faulty thermostat. Check your coolant level at least once a month. Check the

coolant surge tank before you start the engine. If the coolant level is low, pour a 50/50 mixture of water and coolant into the surge tank to the prescribed level.

Check your radiator hoses every time you change your oil. Look for cracks and squeeze the hoses to feel for spongy spots. Replace hoses that are cracked, leaking, or have a spongy feel to them.

Many vehicle manufacturers suggest the cooling system be flushed and replenished with fresh coolant at least once every two years. Check your owner's manual for recommended service intervals for your vehicle.



Cooling system

Fuel and Emission Systems

The purpose of the fuel system is to provide fuel needed for the creation of power to move a vehicle. The fuel system includes a fuel tank, fuel line, fuel pump, air cleaner, fuel filter, and carburetor or fuel-injection system.

The emission (or exhaust) system takes the exhaust created by the burning of fuel, and forces it through the exhaust system to the outside of the vehicle. The system includes the positive crankcase ventilation system (PCV), the exhaust gas recirculation system (EGR), the heat control valve, the catalytic converter, exhaust pipe, muffler, and tailpipe.

Fuel System

The fuel pump draws fuel from the fuel tank through the fuel line. Fuel is then pumped to the **carburetor** or **fuel-injection system.** Air is drawn through the air filter and mixes with the fuel. The fuel–air mixture becomes a fine mist for combustion in the cylinders of the engine.

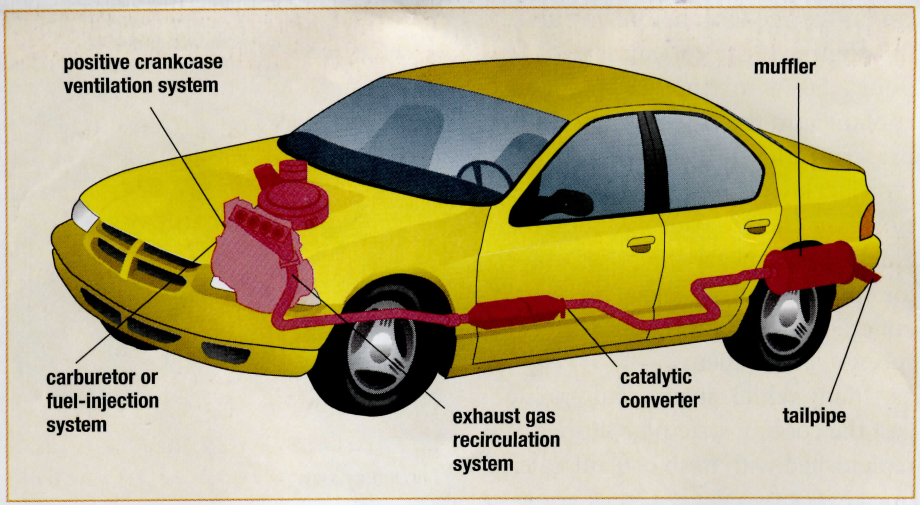
Most new vehicles have electronic fuel-injection systems rather than carburetor systems. Fuel-injection systems deliver the exact amount of fuel to each of the engine's cylinders at the proper time to give maximum power and fuel efficiency. Fuel-injection systems also reduce the amount of pollution-causing gases.

If your vehicle hesitates or sputters while accelerating, or if the "service engine" light comes on, you may need to have your fuel system inspected.

Emission System

The combustion process creates exhaust. The emission system takes the exhaust and recirculates unburned fuel back into the combustion process for greater efficiency. The **catalytic converter** then converts harmful gases into less harmful gases and water. It also cuts down levels of nitrogen oxides, which the sun heats into smog.

Never add water alone to your cooling system. It will boil much faster causing the vehicle to overheat. Use an appropriate water–antifreeze mixture.



Vehicle emission system

The **muffler** reduces the noise from combustion sounds in the engine. Over time, holes develop in mufflers due to rust. If you notice that your vehicle's engine sounds louder and louder over time, it is likely you have a hole in your muffler.

After passing through the muffler, the exhaust leaves the exhaust system through the tailpipe at the rear of the vehicle.

Have your emission system checked periodically to ensure there are no leaks in the system. By doing this, you reduce your risk of carbon monoxide poisoning while driving.

Review It

1. Name at least one warning sign that indicates needed repairs for each of these systems: power, drive, ignition, electrical, lubrication, cooling, fuel, and exhaust.
2. What are the proper steps for starting a vehicle that has a dead battery?

17.2
Maintaining the Control Systems

Objectives

1. Identify the warning signs that might indicate the need for repair of the steering, brake, or suspension systems.
2. Identify ways to maintain tires for longer wear.

Vital to the safe control of your vehicle are several different, but interrelated, systems and components. The steering, brake, and suspension systems are all part of your vehicle's traction-control system. Your tires are also components of your vehicle's traction-control system. All of these contribute to a vehicle's control, stability, and riding comfort.

Steering System

The steering system includes the steering wheel, steering column, steering gear, and the connections to the front wheels. The steering column transmits your steering input to move the front wheels of your vehicle in the direction you choose.

Most vehicles today have **power steering,** a system that uses a hydraulic pump and fluid to make steering easier for you. Avoid turning the steering wheel when the vehicle is not moving. This causes wear on the steering system.

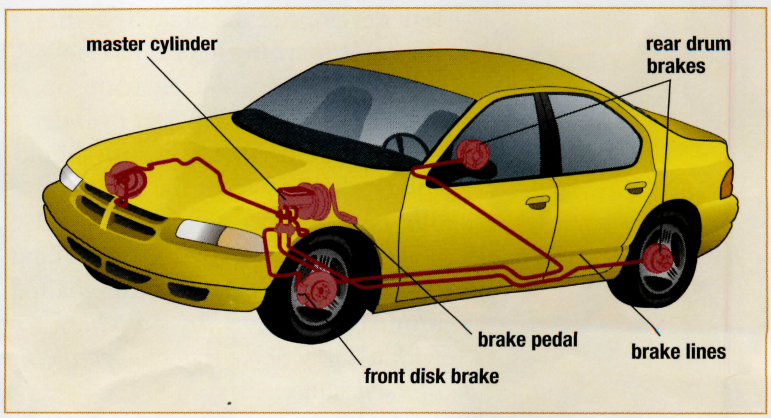
Steering problems often develop gradually rather than suddenly. This may make them difficult to recognize. Any steering problem is serious and should be repaired immediately. Common indications of problems include

- "play" or excess movement in the steering wheel
- steering difficulty, even though the tires are properly inflated
- shimmying or wobbling, or shaking or pulling to one side under normal driving conditions
- squealing sounds when you make turns

Brake System

Good brakes are essential for the safe operation of a vehicle. The life expectancy and performance of your brakes depend on how you use and maintain them. A vehicle's brake system is composed of four individual brakes (one on each wheel), brake lines, brake fluid, wheel cylinders, and a master cylinder.

The brake system's **master cylinder** contains two parts. Each part controls two wheels. When a driver applies pressure on the brake pedal, brake fluid is forced from the master cylinder through the brake lines to each wheel's brake cylinder. The cylinder at each wheel forces the brake shoes or brake pads against a brake drum or disk. The pressure causes friction, which slows or stops the wheel.

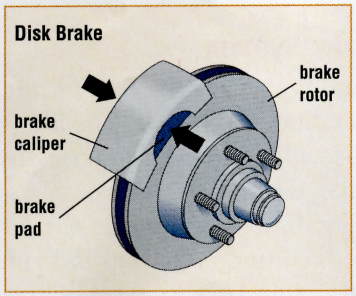


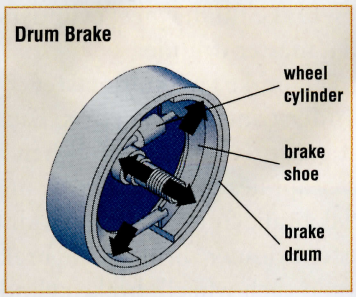
Brake system

DRIVE RIGHT

DID YOU KNOW?

DISK BRAKES AND DRUM BRAKES Many vehicles have a disk brake on each front wheel and a drum brake on each rear wheel. Some vehicles have disk brakes on all four wheels. A disk brake works as fluid pressure presses the pads against the sides of the rotating disk inside the wheel. A drum brake works as fluid pressure forces the brake shoes against the hollow cylinder drum inside the wheel. Each type of brake causes friction that slows or stops the turning wheels.





Most vehicles' brake systems are designed with fail-safe systems. If a leak develops in the brake system, the brake warning light on the instrument panel will likely come on. Because of the dual master cylinder, however, fluid under pressure should still reach one pair of the wheels. Stopping distance will increase and handling may be erratic. The braking system must be checked and repaired immediately. *Never drive a vehicle with a faulty brake system, regardless of the distance.*

A vehicle's disk and drum brakes self-adjust when braking in reverse. If you notice that the brake pedal goes closer than two inches to the floor when you press the brake pedal hard, adjust the brakes. To adjust the brakes, stop, back up, and brake firmly. Repeat this procedure several times. If the problem persists, have your brake system inspected.

If the brake or antilock brake warning light stays on after starting your vehicle or comes on while driving, these are indicators of possible brake problems. Some other indications of potential problems include

- "spongy" feel in the brake pedal
- pulling to one side when stopping with dry brakes
- grabbing or uneven brake action
- squealing or chattering noises in the brakes
- a need to push the brake harder than usual to stop the vehicle

The parking brake is a separate brake system. A steel cable connects the parking brake pedal or lever to a separate brake assembly on the rear wheels only. When properly adjusted and engaged, the parking brake should hold a vehicle on a hill. If the parking brake doesn't hold, have it repaired.

Keep the brake fluid in the master cylinder at the proper level. Use the brake fluid specified for your vehicle. Have your brakes checked on an annual basis, or as soon as you notice potential problems. Proper maintenance of your vehicle's brakes may not only save you money, but could save your life.

Suspension System

The suspension system includes a series of rods, bars, springs, and other components. This system keeps the wheels and tires pointed in the direction you are steering. The springs in the suspension system support the vehicle to allow a gentle up-and-down motion while driving. A shock absorber or strut assembly unit is located at each wheel to control hard bouncing and to keep the tires on the roadway.

If you notice your vehicle bouncing more than usual, or you find uneven tire wear, there may be a problem with its suspension. Check your owner's manual for the recommended intervals for servicing or replacing your vehicle's shocks, struts, and joints.

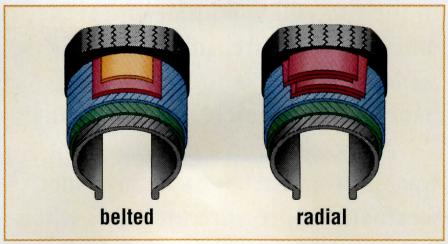
Tires: A Traction Control System

Your tires are your vehicle's lifelines to the roadway. It is important to understand your vehicle's tires and to ensure that your vehicle is equipped with tires that best meet your driving needs.

Tire Construction

A tire is made of rubber reinforced with layers of material under the tread. Each layer, called a *ply,* strengthens the tire and gives it shape.

A **belted tire** has special layers added to a bias-ply tire for improved strength, performance, and mileage. A **radial tire** has plies that run straight across under the tread, and strengthening belts of steel or other materials that circle the tire. Radial tires give improved tread mileage, traction, and fuel economy, compared to other tires.

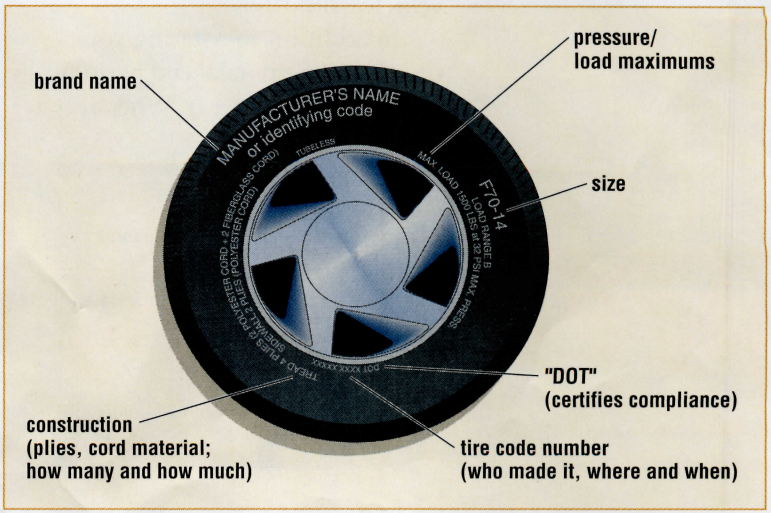


Tire construction

Information about the tire's construction, size, recommended inflation levels, and carrying capacity is clearly marked on the sidewall of the tire. New tires usually have a paper label attached with additional information.

Inflation and Tread

Maintain the manufacturer's recommended air pressure in the tires at all times. Keep a reliable tire gauge in your vehicle and use it regularly. Maintaining the proper air pressure



Information on the sidewall

in the tire will yield maximum fuel efficiency and tire mileage. Too little air in one of your tires can make handling the vehicle more difficult.

Air pressure in a tire rises in warmer weather and falls in cooler weather. Air pressure increases whenever the vehicle is driven, regardless of the distance of the trip. Don't let air out of a warm tire in an attempt to reduce the air pressure to the recommended level. The tire will be underinflated when it cools. Overall, cool tires will provide the most accurate and stable readings.

Rotation and Alignment

Rotate your tires regularly to promote longer tire life. Different rotation patterns are recommended for different vehicles and tires. See your owner's manual for the recommended pattern and schedule you should follow for your vehicle. The illustration shows different rotation patterns for different vehicles and tires.

In addition to rotating your tires, have them balanced periodically to promote even wear. Whenever you have your tires balanced, it is also a good idea to have your wheels aligned. Alignment is especially important on front-wheel drive vehicles. Proper wheel alignment also increases the life of the tires and reduces excessive and uneven wear.

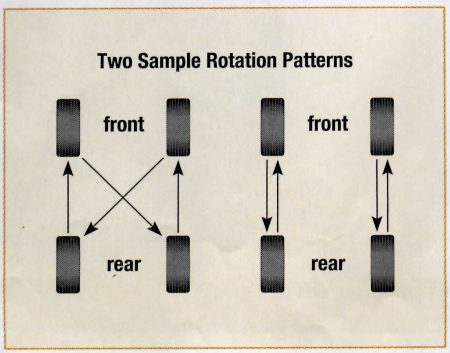
Replacing Tires

Most tires have wear bars built into them. A smooth bar will appear across your tire when the tread has worn down. A worn tire has poor traction on wet roads and is more likely to fail. When you can see one or more wear bars on any tire, it is time to replace that tire.

Replacement tires should be the same size and type as the tires they are replacing. Never use radial tires with any other type of tire on the vehicle. Radial tires do not react the same as belted tires.

Tire Quality and Grading

All tires sold in the United States are rated on the Uniform Tire Quality Grading System, as seen in the chart.



Tire rotation patterns


Notice the wear bar!

Grades of Tires

Tire Grading	Traction	Temperature	Treadwear
Highest	A	A	200 190 180 170 160
	B	B	150 140 130 120 110 100
Lowest	C	C	90 80 70 60 50

- A tire's traction is measured by its ability to stop a car in straight-ahead motion on a wet surface. An A-graded tire has the best traction performance.
- Temperature resistance indicates a tire's ability to withstand heat. A tire graded A is the most heat-resistant, and is the least likely to suffer a blowout under the same conditions as tires with grades of B or C.
- The higher the treadwear rating, the greater the mileage. A tire with a treadwear rating of 150 is expected to last 50 percent longer than one graded at 100.

A tire's performance is measured under ideal controlled conditions on specific test surfaces and over a special test route. They are rated by traction, temperature, and treadwear performance.

Keep safety in mind when you are in need of new tires. Compare and decide which type of tire offers the best value for the kind of driving you do. Check your owner's manual for recommendations on tires for your vehicle.

Review It

1. Identify at least one repair warning sign for the steering, brake, and suspension systems.
2. How can you maintain tires for longer wear?

17.3 Preventive Maintenance

Objectives

1. List preventive maintenance checks to make before and after starting the vehicle, while driving, and when fueling or servicing the vehicle.
2. Explain how to find a qualified mechanic or technician.

The routine care and attention you give your vehicle to avoid trouble later on is called **preventive maintenance.** This attention includes not only the day-to-day care, but also the periodic servicing recommended in your owner's manual.

The schedule of service for maintenance jobs is important. The manufacturer or dealer warranty may not stay in effect if maintenance schedules are not followed.

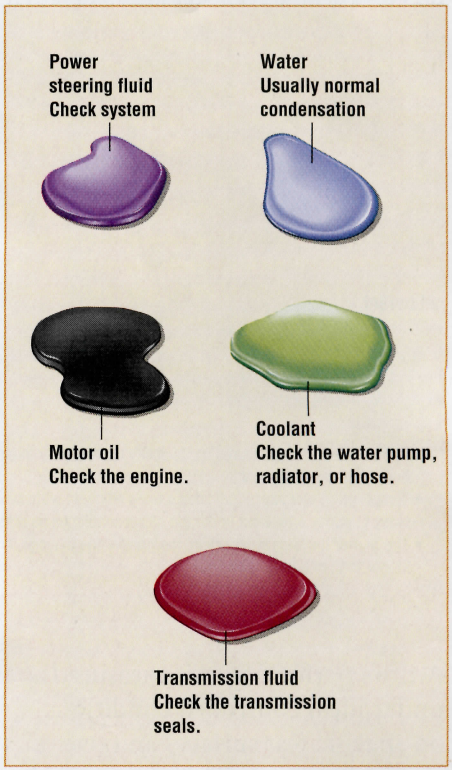
Routine Checks

You should make it a habit to pay attention to your vehicle's condition. Notice changes in its condition before driving and while you drive.

Before Starting the Engine

Before you enter the vehicle and start the engine, make a few quick inspections to avoid trouble while driving. Here are some examples:

- Look for signs of fluid leaks on the pavement under the vehicle. The color and location of the fluid can help you determine the type and source of the leak. The colors in the picture indicate the different types of fluids.
- Make sure your lights and horn work. When you turn the ignition on (without starting the engine) see that your warning lights come on. If one does not come on, check your fuses first. If the fuses are not the problem, then have the vehicle checked by a technician.



Colors indicate the type of fluid leaking out.

After Starting the Engine

After you start your engine, follow the steps and checks as described in Chapter 3. If you have any concerns, see your owner's manual.

While Driving

Follow the steps and procedures you learned in earlier chapters to measure your vehicle's performance. Notice any unusual instrument panel readings. Observe any out-of-the-ordinary sounds, odors, or vibrations of the vehicle.

TIP CONSUMER

How to find leaks: At night, take light-colored paper and place it underneath your vehicle. In the morning, check the paper for fluid spots and their locations. Have any leaks repaired.

At a Fuel Stop

Most drivers fill their own vehicle's fuel tanks at self-service stations. Turn off your engine before you begin refueling. Follow posted instructions for refueling. Smoking is *always prohibited* near fuel pumps.

Almost every gas station offers a selection of types and grades of fuel. Check your owner's manual for your vehicle's recommended octane rating.

Alternative fuels are becoming more common. One type of alternative fuel is gasohol. Gasohol is a blend of gasoline and either methyl or ethyl alcohol.

Whenever you stop for fuel, it's a good time to perform routine checks and service. Here are some examples:

- Check your oil level. Add oil if needed.
- Check the windshield washer fluid level. Add additional fluid to the reservoir, if needed.
- Clean your windshield, windows and headlights.
- Check your windshield wipers for cracks. Replace damaged blades.
- Check your tires. Do they look low? Is the tire pressure correct? Are there any visible cracks in the tire? Take care of crucial problems before you leave the gas station.

Selecting a Qualified Technician

Vehicles are complex machines. It is important that you find a reliable service and repair location staffed with trained and certified technicians and mechanics. Talk with people you know and respect. Ask your local better business bureau. If you are a member of a motor club, ask them for recommendations.

You could also visit different automotive repair shops. Find out if the technicians and mechanics are qualified and certified. Most major dealerships have highly skilled technicians and mechanics who have passed specialized tests to obtain their certifications.

Scheduled Service

Vehicles need periodic service. Your owner's manual shows the recommended maintenance intervals for you to follow. Save all of your service receipts. Keep a comprehensive maintenance history of your vehicle, especially for warranty-related repairs.

State Vehicle Inspections

Some states require periodic vehicle inspections. Inspections can detect safety-related problems before they become hazards. Owners are usually required to have all serious defects repaired before the vehicle can be licensed.

While refueling, clean your windows and check wiper blades for any damage or excessive wear.

Review It

1. List some preventive maintenance checks you should make before and after starting the vehicle, while driving, and when stopping for fuel.
2. List the steps you can take to find a qualified technician or mechanic.

17.4
Fuel-Saving and Recycling Strategies

Objectives
1. Identify ways you can improve a vehicle's fuel efficiency.
2. Explain how to calculate miles per gallon of fuel consumption.
3. Identify strategies for recycling automotive-related materials.

Advancements in design and technology have changed the ways our vehicles look and perform. Today's vehicles are designed and built for greater fuel efficiency. The way you drive can also improve fuel efficiency.

Facts About Fuel Efficiency

Even though vehicle designs and changes in the types of materials used in today's vehicles save fuel, drivers need to follow certain practices to help conserve resources.

Control Your Speed

Many newer vehicles have very fuel-efficient engines that achieve maximum fuel economy at speeds between 50–55 mph. However, strong winds can reduce an engine's fuel efficiency. While driving at speeds of more than 45 mph, keep your windows closed to cut wind resistance.

Higher speeds result in more fuel being used. For every 5 mph increase in speed above 55 mph, most cars get 1.5 fewer miles per gallon.

While driving in the city, coast to a stop when possible, and moderately accelerate to your desired speed. Very fast or very slow starts waste fuel.

Care for Your Engine

Use a vehicle with a warm engine, if you can. A warm engine is more fuel-efficient than a cold engine. The greatest fuel consumption is within the first few minutes after starting a cold engine. The most efficient way to warm up a cold engine is to drive it at moderate speeds for the first few miles. Avoid excessive idling to avoid wasting fuel and possibly damaging the engine.

Calculating Miles Per Gallon

Most drivers want to get the most miles from each gallon of fuel. Checking your fuel economy can warn you of potential mechanical problems. Follow these simple steps to calculate miles per gallon.

1. Fill the fuel tank. Record the odometer reading, or set the trip odometer at zero.
2. Drive normally until you have about a half tank of fuel.
3. Refill the tank. Record the number of gallons it took to refill the tank. Next, record the odometer or trip odometer reading.
4. Subtract the first odometer reading from the second. Then, divide the number of miles driven by the number of gallons of fuel it took to refill the tank. The result is the number of miles per gallon (mpg).

Vehicle Design

The designs of many vehicles have been streamlined to reduce wind resistance and help increase performance and fuel efficiency. Changes in the body shapes, wheel covers, bumpers, and headlights all have contributed to more fuel-efficient vehicles.

Notice how the newer vehicle is more aerodynamic.

In general, vehicles have become smaller and lighter over the years. Lighter-weight materials and plastics have replaced older, heavier steel and metal components. Smaller, lighter vehicles need less power to move. The result has been an increase in fuel efficiency.

Engine Improvements

Because of the types of materials used in manufacturing today's vehicles, smaller engines are common. Smaller engines are designed to provide adequate power for smaller and lighter vehicles. Smaller engines also provide better fuel efficiency.

Electronic ignitions and computerized **engine management systems** help vehicles' engines operate and use fuel efficiently. A computer monitors the fuel, ignition, and emission systems. The computer collects data about each system and automatically

Dispose of used fluids responsibly.

makes adjustments to the respective systems. These adjustments increase operational efficiency.

For example, the air–fuel mixture introduced into the cylinders is more precise and is burned more effectively as a result of the engine management systems. Less fuel is burned, and it is burned more efficiently. The result is greater fuel efficiency and fewer hazardous gases emitted into the atmosphere.

Recycling Strategies

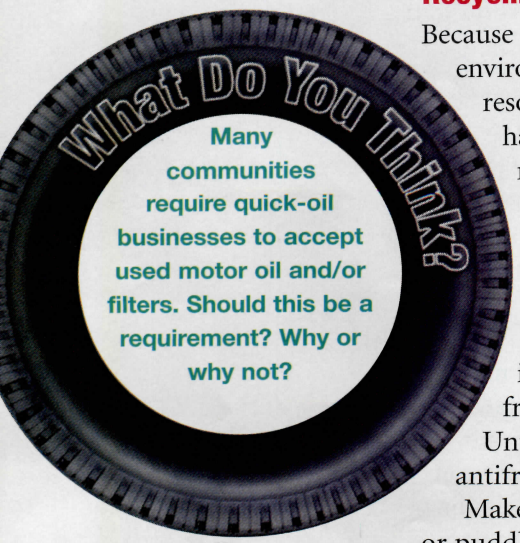
Because of the concern over the environment, conservation of resources, and potential health hazards, many automotive materials are being recycled for reuse or turned into other consumer products.

Any materials meant to be used later, and not discarded, should be placed in sealed containers away from children and pets. Unused oil, gasoline, and antifreeze are just a few examples.

Make sure oil and antifreeze spills or puddles are promptly absorbed and cleaned from your driveway or garage. The sweet smell and taste of antifreeze could attract children and animals. If ingested, oil or antifreeze could poison and potentially cause death.

Many states have regulations for recycling oil and engine contaminants. Items that can be recycled, such as used motor oil, antifreeze, and batteries, should be taken to respective recycling centers, local drop-off locations, or hazardous waste collection locations.

If you have your vehicle serviced at an automotive service station or vehicle maintenance facility, you avoid the responsibility of having to handle or dispose of used parts, materials, and fluids. Businesses that service vehicles know how to properly deal with used automotive materials.



Review It

1. What are some ways to improve the fuel efficiency of your vehicle?
2. Explain how to calculate miles-per-gallon of fuel consumption.
3. What are at least three examples of automotive-related items that can be recycled?

Chapter 17 Review

Reviewing Chapter Objectives

1. Maintaining the Power Systems

1. What are the signs that repairs are needed for the power and drive systems, lubrication and cooling systems, and fuel and exhaust systems? (356–362)
2. What steps should you follow to start a vehicle that has a dead battery? (358–359)

2. Maintaining the Control Systems

3. What are the signs that repairs are needed for the steering, brake, and suspension systems? (363–369)
4. How can you maintain tires for longer wear? (366)

3. Preventative Maintenance

5. What are the preventive maintenance checks to make before and after starting the vehicle, while driving, and when fueling or servicing the vehicle? (368–369)
6. How can you find a qualified mechanic or technician? (369)

4. Fuel-Saving and Recycling Strategies

7. In what ways can you improve a vehicle's fuel efficiency? (370)
8. How do you calculate miles per gallon of fuel consumption? (370)
9. What are the strategies for recycling automotive-related materials? (372)

Projects

Individuals

Interview Make a list of certified vehicle technicians and mechanics in your area. Interview three of them to find out what their qualifications are. Ask them how long they have been in business and what they like best about their job. Determine which one you would want to repair your vehicle.

Investigate Use the Internet to research ways that vehicle manufacturers recycle various components of their products. Write a report based on your research and share it with the class.

Groups

Use Technology Make a video about the preventive maintenance checks you should make on your vehicle. Each group member should explain a different aspect of preventive maintenance. Get an owner's permission to use an actual vehicle in your video. Present the video to your class.

Observe Each person in the group should check out the tires on ten vehicles in the school's parking lot. Note whether each tire is belted or radial. Note whether the tire is inflated properly and had adequate tread. Make a group spreadsheet based on each person's findings.