4 Overview of the Task List

Suspension and Steering (Test A4)

The following section includes the task areas and task lists for this test and a written overview of the topics covered in the test.

The task list describes the actual work you should be able to do as a technician that you will be tested on by the ASE. This is your key to the test and you should review this section carefully. We have based our sample test and additional questions upon these tasks. The overview section will also support your understanding of the task list. ASE advises that the questions on the test may not equal the number of tasks listed; the task lists tell you what ASE expects you to know how to do and be ready to be tested upon.

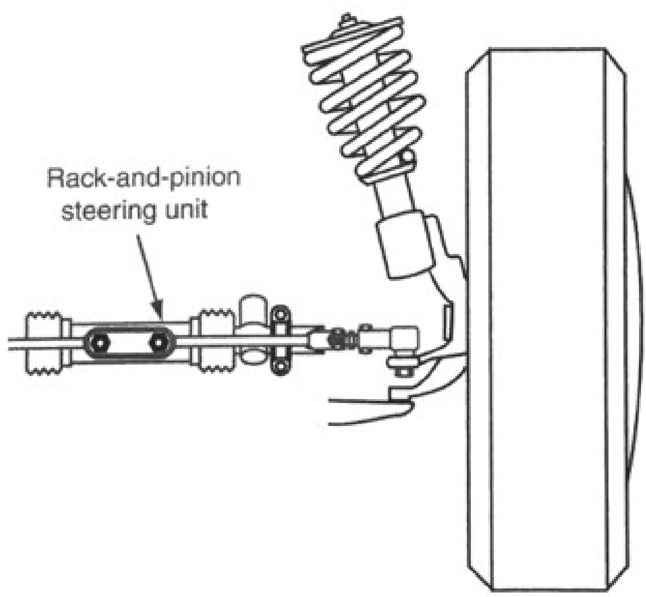
At the end of each question in the Sample Test and Additional Test Questions sections, a letter and number will be used as a reference back to this section for additional study. Note the following example: **A.3.1**

A. Steering Systems Diagnosis and Repair (10 Questions)

Task A.3 **Steering Linkage (3 Questions)**

Task A.3.1 **Inspect and adjust (where applicable) front and rear steering linkage geometry (including parallelism and vehicle ride height)**

Example:



1. An inspection is being performed on the rack and pinion steering system shown in the figure. All of the following should be checked **EXCEPT:**

A. the ball joints.
B. the tires.
C. the Pitman arm. (A.3.1)
D. the tie-rods.

Analysis:

Question #1
Answer A is wrong. Ball joints should be inspected within the steering system for wear and looseness.
Answer B is wrong. Tires should be inspected along with the steering system for abnormal wear.
Answer C is correct. A rack and pinion steering system does not have a Pitman arm.
Answer D is wrong. Tie-rods should be inspected as part of the steering system for wear and looseness.

Task List and Overview

A. Steering Systems Diagnosis and Repair (10 Questions)

Task A.1 Steering Columns (3 Questions)

Task A.1.1 Diagnose steering column noises and steering effort concerns (including manual and electronic tilt and telescoping mechanisms); determine needed repairs.

The steering column is the direct connection from the steering wheel to the steering gear. Although there are many designs, some basic characteristics apply to most columns. On all new vehicles, there is an air bag located in the center of the steering wheel. Most vehicles will incorporate (in the steering wheel and column) functions such as turn signals, headlights, hazard lights, ignition lock, horn, ignition switch, wipers, windshield washers, and cruise control switches. Some designs will also have additional features such as radio volume and station switching. A wiring harness runs alongside the column.

To add to driver comfort, many steering columns tilt and may even telescope up and down.

Diagnosing steering complaints always begins with a complete inspection of the **steering column**. Worn steering column bearings or loose mounts can cause noise and looseness in the steering column. Check for excessive up-and-down and side-to-side movement in the steering wheel and column. A broken support plate or other worn internal column parts can cause looseness or binding in the steering column.

In a **tilt steering column**, worn or loose pivots that allow the column to tilt will result in excessive steering wheel movement. In many cases, it will be necessary to remove the steering wheel and disassemble the steering column to properly identify the worn parts.

Task A.1.2 Inspect and replace steering column, steering shaft U-joint(s), flexible coupling(s), collapsible columns, and steering wheels (includes steering wheels and columns equipped with air bags and/or other steering wheel/column mounted controls, sensors, and components).

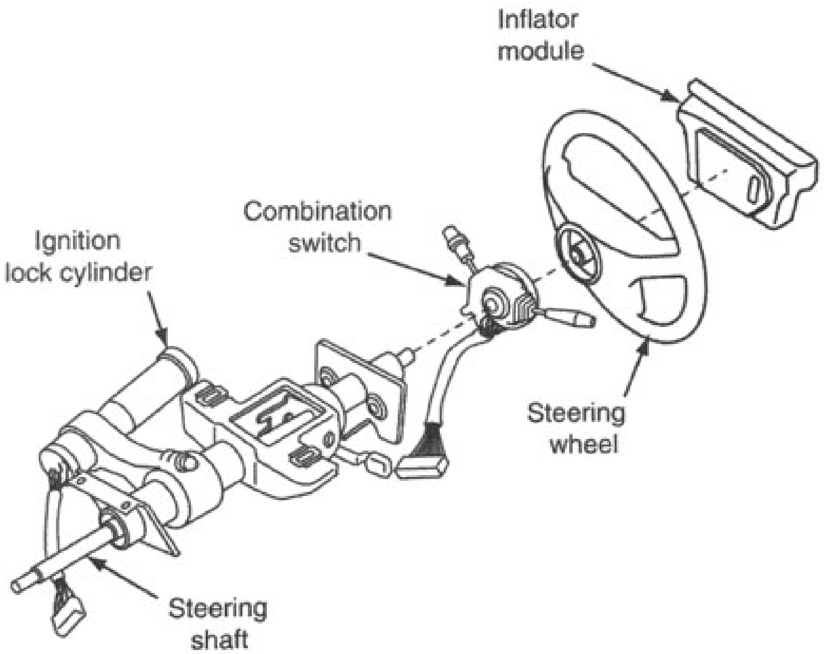
Before removing the steering column, point the front wheels in the straight-ahead position and make sure the column is in the lock position. This will prevent damage to the air bag clock spring (spiral cable) and will help line-up the steering column with the steering gear during reassembly. For vehicles equipped with air bags, disable the air bag system following the manufacturer's procedure. Usually, this involves removing the battery cables or air bag fuse.

After removing the horn pad (and/or air bag), remove the steering wheel retaining nut and check alignment marks on the steering wheel and shaft. If no marks are found, scribe marks to ensure proper reinstallation of the steering wheel. Using the proper puller, remove the steering wheel. Never use a hammer, slide-hammer, or knock-off puller to remove the steering wheel. Damage to the column or column bearings can result.

Disconnect the wiring harness, bottom steering coupler retaining bolt, and transmission linkage from the column. Mark the position of the steering column coupler to the steering gear. Remove, if necessary, any dash trim to gain access to the steering column mount under the dashboard. Carefully remove the steering column from the vehicle.

Inspect all external components including the flex coupler and lower column U-joint (if equipped). Many vehicles are designed with an intermediate shaft containing two U-joints. Inspect the U-joints for wear, looseness and binding. Disassembly of the steering column will be necessary to inspect internal components of the column.

Task A.1.3 Disarm, enable, and properly handle airbag system components during vehicle service following manufacturers' procedures.

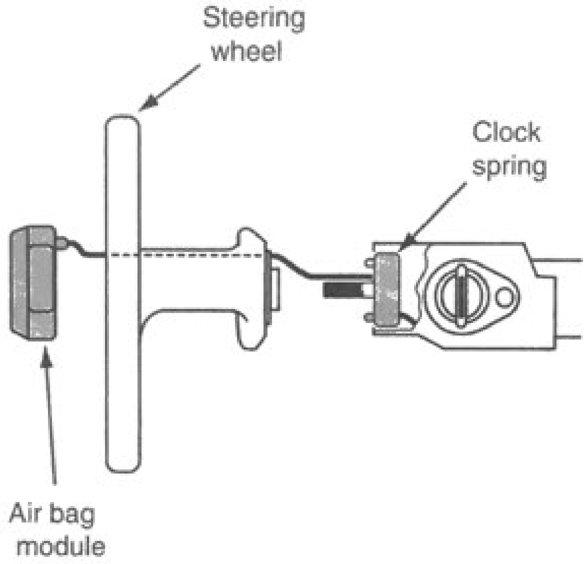


The supplemental inflatable restraint system (air bag) must be disarmed properly before any work is performed on the steering column. Failure to disarm the air bag may result in the accidental deployment of the air bag, which can cause personal injury and unnecessary repairs to the air bag system. Always consult the service manual for recommended procedures on disabling the air bag system.

The following is a list of basic procedures and precautions that should be followed when working with and around air bag systems.

- Always disable the air bag system before servicing the air bag or any components near or around the steering column and/or air bag system.
- Never subject the inflator module to temperatures greater than 175°F (79.4°C).
- If any air bag component is dropped, it should be replaced.
- Never test any air bag component with electrical test equipment unless instructed to do so by the factory service manual.
- When carrying a live (not deployed) air bag, always point the bag and trim cover away from you.
- When placing a live air bag on a workbench, always face the air bag and trim cover up.
- Discarded live air bags must be deployed. Follow manufacturer's procedure for proper disposal.
- Lock the steering wheel in place whenever removing the steering wheel, steering column, or steering gear to prevent damage to the clock spring. The clock spring maintains a continuous

electrical connection as the steering wheel rotates between the inflator module and air bag controller.



Task A.2 Steering Units (4 Questions)

Task A.2.1 Diagnose steering gear (non-rack and pinion type) noises, binding, vibration, free play, steering effort, steering pull (lead), and leakage concerns; determine needed repairs.

Conventional steering gears utilize the **recirculating ball design.** Many conventional steering gear problems are due to internal wear. Start your steering inspection by turning the steering wheel full left and full right, noting any noise, binding, roughness, looseness, or need for excessive effort. Check lubrication level. Inspect the steering gear for indications of fluid leakage from the gear and at hose connections for power steering units. Loss of fluid may cause increased steering effort and erratic steering. Fluid loss on power steering units may cause a whine or growling noise. A loose or worn power steering belt may cause a squeal while turning the steering wheel, and may also cause erratic steering and increased steering effort. On power steering systems, a missing belt will result in loss of power steering assist.

A worn sector shaft, worm shaft, or bearings can cause binding and roughness while turning the steering wheel. Excessively worn steering gears will have to be either overhauled or replaced.

Inspect the steering gear mounting bolts. Loose gear-to-frame mounting bolts will cause excessive free play, wandering, and may even cause a vibration. Inspect the frame where the steering gear is mounted for corrosion and cracks. Rust can weaken the frame and cause the gear to flex or pull away causing a potentially dangerous situation.

Task A.2.2 Diagnose rack and pinion steering gear noises, binding, vibration, free play, steering effort, steering pull (lead), and leakage concerns; determine needed repairs.

Most new vehicles are equipped with a **rack and pinion** steering gear. The rack and pinion steering gear is a much simpler design. The steering column is connected directly to the sector shaft, called the pinion. The pinion operates the rack assembly, which moves the tie-rods and the steering knuckles. On power steering rack and pinion gears, a control valve directs the flow of fluid from one side of the rack to the other.

Diagnose problems with a rack and pinion steering gear following the same basic procedures as with the conventional steering gear. Turn the steering wheel full left and full right, noting any noise, binding, roughness, looseness, or need for excessive effort. Inspect the mounting brackets and bushings for wear, which can cause loose or wandering steering. A binding or roughness while turning the wheel may indicate a worn rack gear. A worn steering rack may also cause excessive steering effort. Carefully inspect the rack for leaks at the bellows boots and at the pinion seal.

Task A.2.3 Inspect power steering fluid level and condition; determine fluid type and adjust fluid level in accordance with vehicle manufacturers' recommendations.

Power steering fluid reservoirs are either integrated with the pump or remotely located. Many remote reservoirs are transparent and have markings on the outside to indicate the fluid level. Remote reservoirs are usually marked: **FULL COLD, FULL HOT**, or **MIN, MAX**. If the fluid is checked with a dipstick, wipe the cap and area clean to prevent dirt from entering the system.

Check the fluid level at normal operating temperature (approximately 175°F.). Make sure the fluid level is at least MIN or COLD before running the engine to prevent damage to the pump or gear. A low fluid level may indicate a leak.

When checking the fluid level, note the fluid condition. Discolored fluid or signs of particles may be an indication of wear to the pump, hoses, or gear. Foamy fluid is caused by air in the system.

Before adding fluid, check with the factory manual for the proper fluid.

Task A.2.4 Inspect, adjust, align, and replace power steering pump belt(s) and tensioners.

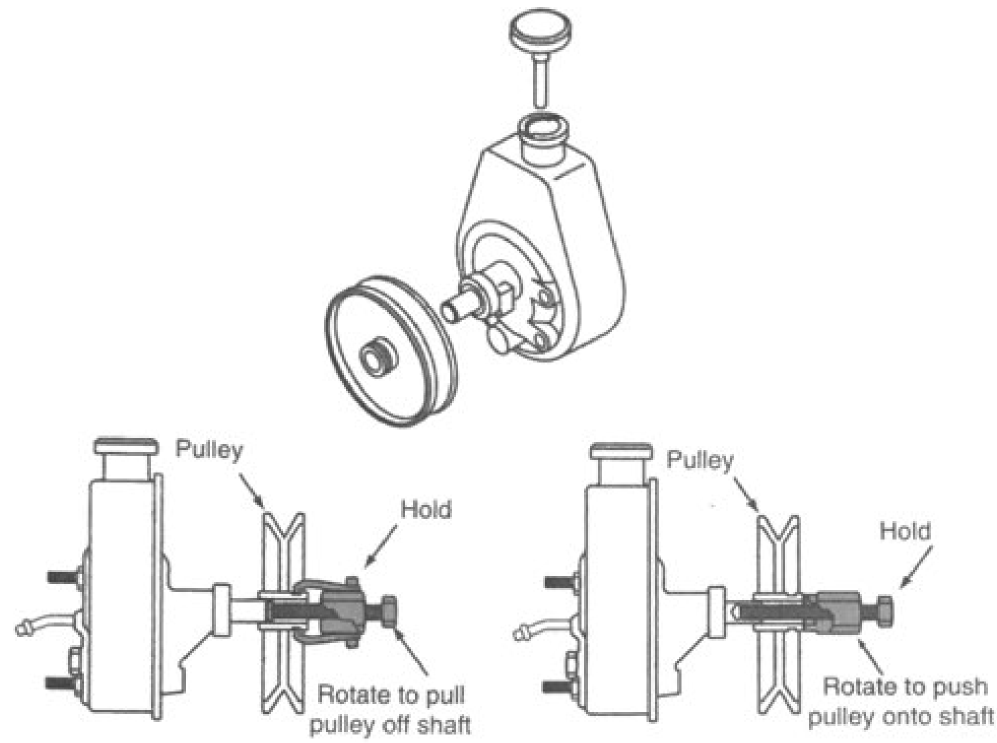
The power steering pump is driven by either a conventional V-belt or serpentine belt. Most new vehicles are equipped with serpentine belts that incorporate automatic tensioners. Older belt systems must be adjusted manually.

Belts should be inspected for glazing, rotting, cracking, or swelling. Oil residue on the belt may be an indication of a fluid leak. Also, always check for proper pulley alignment when inspecting or replacing belts. Belt tension must also be checked on both automatic tensioners and on manually adjusted belts. Use a belt deflection gauge or use the deflection method by applying pressure with your finger on the belt midway between the longest span. Compare your reading with manufacturer's specifications. Typical belt deflection is approximately 0.5 inch (12.7mm).

For automatic tensioners, inspect for wear, looseness, and binding. Replace if worn.

Task A.2.5 Diagnose power steering pump noises, vibration, and fluid leakage; determine needed repairs.

The power steering pump supplies the hydraulic pressure needed to operate the steering gear. The most common problem with the pump is seal leaks. Loss of fluid will cause an audible whine or growling noise. Seal leaks will require either pump replacement or an overhaul. If a vibration is felt when turning the steering wheel, check for belt problems, internal pump problems, or loose pump retaining bolts and mounting brackets.



Task A.2.6 Remove and replace power steering pump; inspect pump mounting and attaching brackets; remove and replace power steering pump pulley.

To remove the power steering pump, start by removing the belt and cleaning any dirt around the pump and hose connections. Disconnect the hoses and plug the hoses and pump fittings. Remove the pump mounting bolts and carefully remove the pump from the vehicle. On some vehicles, it will be necessary to remove the pulley before the pump can be removed from the mounting bracket. To remove and install the pulley, always use the proper puller. Never attempt to hammer the pulley off or on. With the pump removed, inspect the mounting brackets.

After installing the pump, fill with fluid, bleed the system, and check for leaks. Also check belt tension and for proper pulley alignment. Road test the vehicle and recheck fluid level and for leaks.

Task A.2.7 Inspect and replace power steering pump seals, gaskets, reservoir, and valves.

Leaking seals and worn parts will require a pump overhaul or replacement. Worn or leaking pumps are usually replaced. However, many times leaking pumps can be resealed. If an overhaul is elected, consult the factory manual first for details and proper procedures.

With the pump removed from the vehicle, drain as much fluid as possible, remove the pulley, and disassemble the pump. Carefully lay out the parts on a clean workbench. Inspect all internal parts, flow control valve, and seals for damage, galling, nicks, and excessive wear.

On pumps with integrated reservoirs, a common location for a leak is from the reservoir seal. Remove the O-ring fitting and mounting bolts. Carefully twist the reservoir and remove the reservoir from the pump housing. Clean the reservoir, mounting area, and seal area. Replace the reservoir seal and reassemble. Lubricate the seal with power steering fluid prior to installation.

The shaft seal is another common cause for leaks. To replace it, first remove the pulley. Pry out the old seal and install the new seal using a suitable seal driver.

When replacing the flow control valve, lubricate the new valve with power steering fluid and install it in the pump housing.

After repairs are made, add new power steering fluid, check for leaks, bleed system, and road test. Check for proper power steering operation. Bleeding procedures are covered in Section A.2.16 of this manual.

Task A.2.8 Perform power steering system pressure and flow tests; determine needed repairs.

Increased power steering effort or lack of power steering assist can be caused by problems in the pump or gear. Checking system pressure can help determine the cause of the problem.

Before starting pressure testing, check fluid level and fill to proper level. Run the engine until normal operating temperature is achieved. Make sure the engine idle is correct and check belt tension. Obtain manufacturer's specifications for the vehicle being tested.

Install a power steering pressure gauge tool on the pressure side between the pump and the gear. Position the shutoff valve toward the power steering gear. Start the engine and record the pressure in the straight-ahead position with the gauge valve open. If the pressure reading is above specification, check for restricted hoses or a damaged steering gear.

Next, turn the steering wheel full left or full right and hold the wheel against the stop for no more than five seconds. Record the maximum pressure attained and check factory specification. Typical pressure readings are generally over 1,000 psi. If the pressure reading is below specification, position the steering wheel in the straight-ahead position and slowly close the shutoff valve. If the pressure rises to the proper specification with the shutoff valve closed, the pump is working correctly. Look for problems in the hoses or gear assembly. If the pressure does not rise with the shutoff valve closed, the problem is in the pump. Do not leave the shutoff valve closed for more than five seconds. If the pressure is okay with the shutoff valve closed, but fails to reach sufficient levels when the steering wheel is turned full left or full right, then the steering gear is faulty.

Task A.2.9 Inspect and replace power steering hoses, fittings, O-rings, coolers, and filters.

Power steering hoses are designed to withstand the extreme high pressure developed by the power steering pump and the high temperatures generated under the hood. Inspect power steering hoses for leaks, cracks, swelling, and physical damage. Always replace a power steering hose with one specifically designed for the vehicle on which you are working. Hoses must be routed and mounted correctly.

Some hose fittings use O-ring seals. Always replace the O-ring when replacing a power steering hose. Tighten the new hose to correct specification and check for leaks.

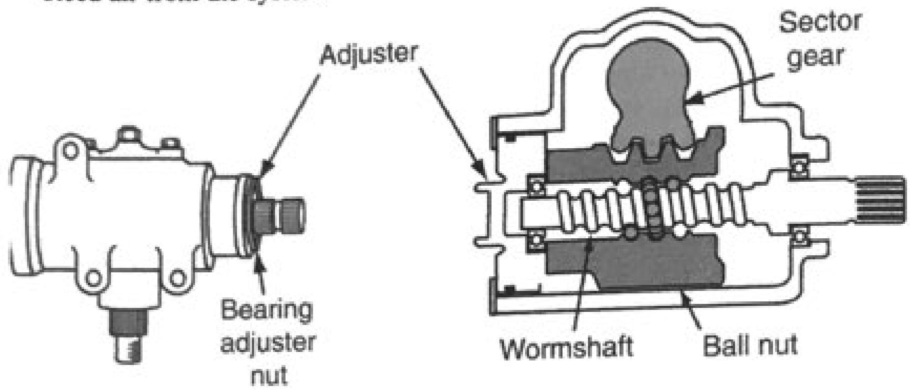
Many power steering systems use coolers to maintain proper fluid temperature. Inspect coolers for leaks and damage. Filters are often used to trap particles that may damage internal components.

Task A.2.10 Remove and replace steering gear (non-rack and pinion type).

The following are the basic steps to remove and replace a power steering gear.

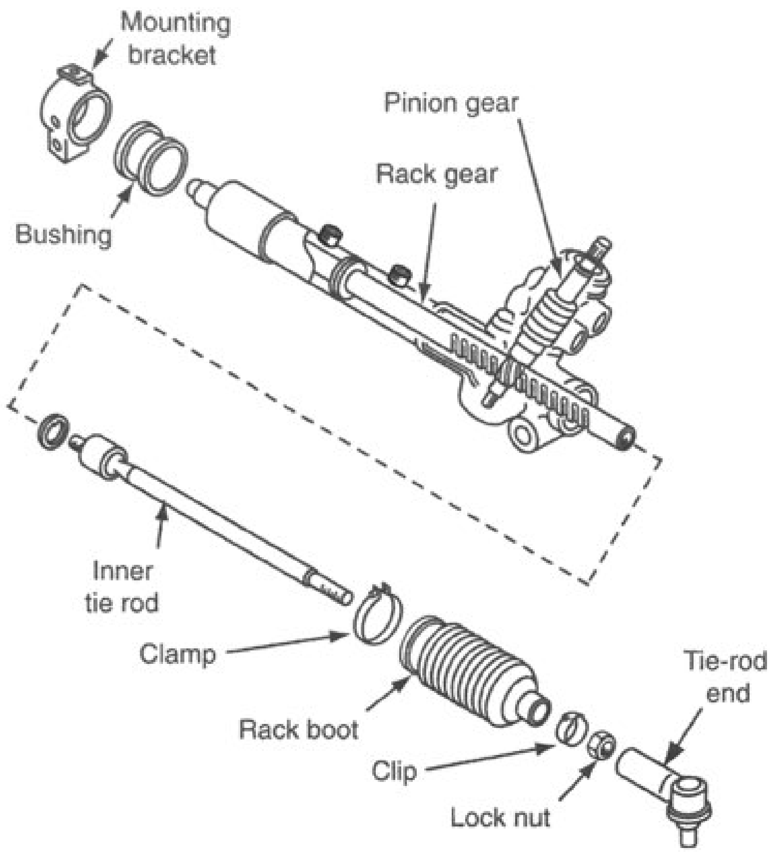
1. Determine if the steering column must be removed or loosened inside the vehicle. If it must be removed or loosened, proceed as follows. If not, proceed with under-car and under-hood operations beginning with step 2.
    1. Disconnect the battery ground cable or remove the air bag fuse, or fuses, if equipped. If the vehicle has air bags, wait two to five minutes before proceeding.
    2. Disconnect electrical connectors from the steering column under the instrument panel.
    3. Loosen or remove the steering column mounting bolts from the instrument panel bracket.
4. Disconnect the power steering hoses from the steering gearbox and drain the fluid into a suitable container.
5. If necessary for access, remove the power steering pump and any other engine-driven accessories, as required.
6. Disconnect the steering column from the steering gearbox.
7. Remove the Pitman arm from the gearbox sector shaft using a suitable puller.
8. Unbolt the steering gearbox from the chassis and remove it from the vehicle.
9. Reinstallation is the reverse of removal. Properly torque all retainers to specification.

10. After installing the steering gearbox and reconnecting the hoses, fill the pump with fluid and bleed air from the system.



Task A.2.11 Remove and replace rack and pinion steering gear; inspect and replace mounting bushings and brackets.

1. Before removing the rack and pinion gear from the vehicle, point the front wheels in the straight-ahead position.
2. If the vehicle is equipped with an air bag, it is important to lock the steering wheel in place. If the steering wheel rotates while not connected to the gear, damage will occur to the air bag clock spring.
3. Disconnect the steering column coupling or U-joint from the steering gear. Mark the position of the steering column shaft and steering gear to ensure correct alignment during reassembly.
4. Remove the outer tie-rods from the steering knuckle and remove the mounting bolts. The rack and pinion will be either bolted to the frame or to the engine cradle.
5. Remove the rack and pinion gear from the vehicle and carefully inspect for signs of damage and leakage.
6. Check for wear in the rack pinion and inner tie-rods. Inspect the rack bellows boots.
7. Inspect the mounting brackets and bushings for wear. Replace worn or damaged bushings and brackets.
8. When reinstalling the rack, torque all retainers to specification. If the engine cradle was loosened, make sure it is aligned properly during reassembly.



Task A.2.12 Adjust steering gear (non-rack and pinion type) worm bearing preload and sector lash.

Worm bearing preload affects steering effort. Too little bearing preload and the steering will feel loose. Too much preload and the steering will feel tight or stiff. To check worm bearing preload, remove the Pitman arm and the horn pad assembly. With an inch-pound torque wrench, slowly rotate the steering wheel to the left and to the right by using the steering wheel retaining nut. Note the reading while rotating the steering wheel and compare with manufacturer's specification. If an adjustment is needed, loosen the worm shaft bearing locknut. To increase bearing preload, tighten the adjuster nut. To decrease preload, loosen the adjuster nut. After the adjustment is made, turn the steering wheel to the left and to the right. If any roughness or binding is felt, the steering gear may be worn and may have to be replaced. Some systems use shims to adjust preload. Removing shims will increase preload; adding shims will decrease preload.

Sector shaft lash determines how much free play there is in the steering wheel, produced by the steering gear and not by the steering linkage. To check sector lash, remove the Pitman arm and horn pad, as before, and determine the exact center of the steering gear. Rotate the steering wheel to the left one-half turn. Using a inch-pound torque wrench, measure the steering wheel's resistance as it is turned to the right, passing the center point, and continuing until the steering wheel is rotated one full turn. Check your reading against factory specification. If adjustment is required, loosen the sector shaft adjusting lock nut and turn the adjusting screw as required.

Task A.2.13 Inspect and replace steering gear (non-rack and pinion type) seals and gaskets.

Leaking steering gears often means that there is considerable wear, and replacement of the gear is required. Carefully inspect the steering for excessive wear before recommending seals or gasket replacement. Consult the factory manual for procedures and specifications. The steering gear may have to be removed from the vehicle in order to replace some seals.

Thoroughly clean the exterior of the gear before starting the repair. Carefully disassemble the section of the steering gear being repaired and inspect and clean all parts. A scored power steering gear cylinder increases steering effort, but it does not contribute to road shock on the steering wheel. Replace worn seals and gaskets as needed. Use appropriate tools to install seals, as required. After reassembly, check and perform any necessary adjustments and check for leaks.

Task A.2.14 Adjust rack and pinion steering gear.

Two adjustments may be possible on a rack and pinion assembly:

1. Pinion torque is the force needed to turn the pinion gear along the rack. It is adjusted by turning an adjustment screw or a threaded cover on the rack housing or by adding or removing shims under the rack support cover.
2. Pinion bearing preload is the force that the pinion bearings place on the pinion shaft. Only a few steering assemblies have adjustable pinion bearing preload. When it is adjustable, adjustments are made by adding or removing shims or by turning an adjustment collar at the base of the pinion gear.

Most vehicles will require that the rack and pinion assembly be removed for adjustment. On some vehicles, you may be able to disconnect the steering shaft and the tie-rods and make the adjustments on the car. The steering shaft and tie-rods must be disconnected to remove all steering load from the rack and pinion assembly.

Task A.2.15 Inspect and replace rack and pinion steering gear bellows/boots.

The rack and pinion bellows boots protect the inner ball sockets on most designs and the rack seals. The boots contract and expand with the turning of the wheels. Inspect the bellows boots for wear and for fluid seepage. Leaking fluid is an indication of a defective seal or worn rack and pinion. If a bellows boot is cracked, dirt and moisture may have entered. Inspect the inner tie-rod for wear.

To replace the boots, it will be necessary to remove the outer tie-rod and tie-rod locking nut on some models. Mark the position of the tie-rod in order to maintain proper toe alignment during reinstallation. Remove the bellows boot retaining clamps and slide the boot off. Replace the boots using new retaining clamps. On vehicles where the tie-rod is removed, it is important that the wheel alignment be checked after reassembly.

Task A.2.16 Flush, fill, and bleed power steering system.

Flushing the power steering system is accomplished by disconnecting the return to the pump. Plug the pump return port and fill the power steering reservoir with the recommended fluid. With the front wheels off of the ground and the return hose in a drain pan, start the engine and slowly turn the steering wheel from stop to stop. Flushing the system with two quarts of power steering fluid should be sufficient to remove all contaminants and foreign material. Cleaning solvent should never be used in power steering systems for cleaning or flushing procedures. Power steering pumps need power steering fluid to distribute load forces and to prevent excessive heat buildup.

After a repair has been made to the power steering system, bleeding will be necessary to remove trapped air and to obtain a correct fluid level. Refer to the factory manual for bleeding procedures on the specific vehicle being serviced. A typical bleeding procedure is as follows:

- Fill the system with the correct fluid.
- Allow the engine to run for a few minutes without turning the wheels.
- Shut the engine off and let the vehicle sit for a few minutes.
- Recheck the fluid level and refill if needed.
- Start up the engine again and run it for a few minutes. Turn the wheels full left and full right.
- Recheck the level and add fluid, if needed. Repeat the last two steps until the fluid level no longer drops.

- Inspect the entire system for leaks.
- Road test the vehicle and check for correct power steering operation.
- After the road test, check fluid level and add if necessary.

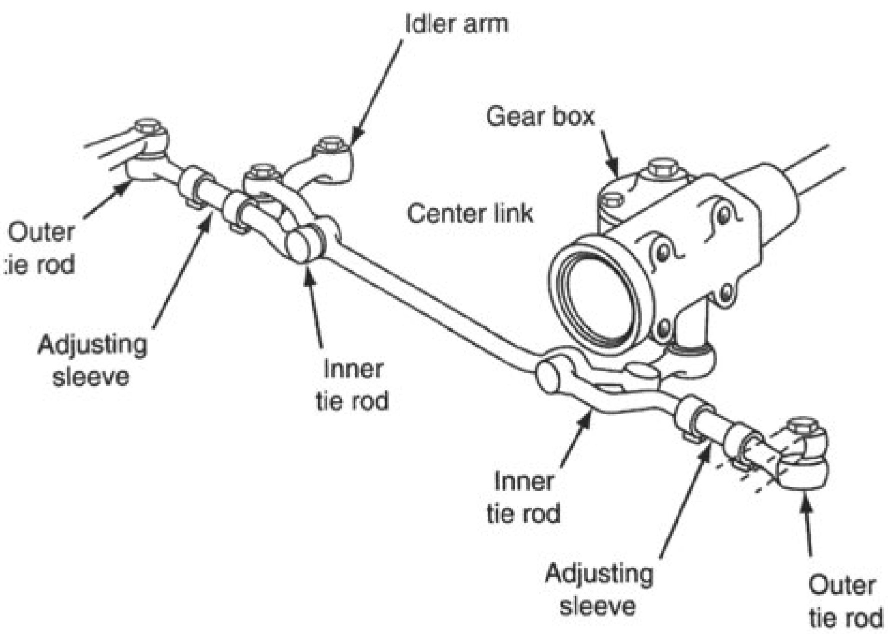
Task A.2.17 Diagnose, inspect, repair, or replace components of variable-assist steering systems.

In a variable-assist steering system with a steering wheel rotation sensor, the hydraulic boost increases when the steering wheel rotation exceeds a specified limit. Power steering assist also is increased at low speeds and decreased at higher speeds.

The system is designed to provide better feel and control at higher vehicle speeds. The variable steering systems are usually designed to start firming up the steering at speeds over 25 mph (40 km/h) and to reach the maximum firmness between 60 and 80 mph (97 and 129 km/h), depending on design. On most vehicles, the main input for the variable-assist steering systems is the vehicle speed sensor, but some manufacturers also use a steering wheel rotation sensor so the vehicle will revert to full assist during evasive maneuvers. On most vehicles, the system goes to full assist below 25 mph (40 km/h).

Pump pressure is controlled by a variable orifice or pressure control valve. Hydraulic pressure is reduced or gradually reduced as vehicle speed increases. Problems within the system may cause a noticeable change in the amount of steering effort at different speeds. The steering may feel stiffer at low speeds or lighter at high speeds. A faulty speed sensor will prevent the system from operating properly. On computerized systems, the controller will put the system in full assist mode at all speeds and steering maneuvers if a fault is detected.

Task A.3 Steering Linkage (3 Questions)



Task A.3.1 Inspect and adjust (where applicable) front and rear steering linkage geometry (including parallelism and vehicle ride height).

The two most common steering linkage designs in use today are the **rack and pinion system** and the **parallelogram design**. The parallelogram is a much more complicated system that uses a conventional steering gearbox.

A variation of the parallelogram design is the cross steer linkage system used on some four-wheel-drive vehicles. The cross steer linkage uses one long tie-rod that is connected to both the left and right steering arm. A drag link connects the left steering arm to the steering gearbox. Some cross steer systems use an adjustable tie-rod drag link, which is used to center the steering wheel.

On all vehicles, a complete periodic inspection of the steering linkage is required due to normal wear and tear of the steering components. All nuts and cotter pins should be in place, and inspected for leaking grease seals. Excessive wear in a steering linkage component will result in inadequate steering performance and can cause tires to wear unevenly.

Also, check the steering linkage for bent or damaged components. A bent component, such as a tie-rod or center link, can affect steering ability and may cause irregular tire wear. Check vehicle ride height when performing a routine linkage inspection. On some vehicles equipped with torsion bars, ride height can be adjusted. On most vehicles, if ride height is incorrect, suspect worn or broken springs. Many vehicles are equipped with rear linkage systems and are susceptible to the same problems as in the front linkage system. Perform a complete inspection of the front and rear linkage systems. On conventional steering linkage (parallelogram), the steering linkage must be parallel to the chassis. Assuming the chassis is level, the simplest method is to measure from both ends of the centerlink to the floor. If the centerlink is unleveled, the idler arm is usually adjustable to correct this problem.

Task A.3.2 Inspect and replace Pitman arm.

The main reason for changing Pitman arms is vehicle crashes. Pitman arms are very well built and the splines do not loosen from road shock. The Pitman arms can be bent or broken in vehicle crashes; but more often sector shafts are bent and broken. If the Pitman arm has a ball and socket at one end, it should be replaced when the ball and socket show any looseness.

To remove the Pitman arm, remove the nut and lock washer first. Some Pitman arms are indexed to the sector shaft. If not, scribe an alignment mark on the Pitman arm before it is removed. This will ensure proper alignment during reinstallation. Using the appropriate puller, remove the Pitman arm. When installing the Pitman arm, make sure it is indexed correctly and torque retaining nuts to specification.

Task A.3.3 Inspect and replace center link (relay rod/drag link/intermediate rod.

A bent or damaged center link can cause incorrect toe alignment, front-wheel shimmy, and possibly tire wear. Inspect the center link for worn joints and for physical damage. To remove the center link, remove the cotter pins and nuts and separate the joints using a separator fork or puller. After installing the center link, properly torque all retaining nuts and replace the cotter pins. If the holes for the cotter pin do not line up after torquing the nuts, continue to tighten the nut until they do. DO NOT loosen the nut to align the hole.

Task A.3.4 Inspect, adjust (where applicable), and replace idler arm(s) and mountings.

The function of the **idler arm** is to hold the right side of the center link level with the left side of the steering linkage. The idler arm is set at the exact same angle, and is the same length as the Pitman arm. The weakest point on the idler arm is the bushing. A worn idler arm bushing will cause excessive movement in the arm, which can cause changes in toe alignment and loose steering. Some idler arms have replaceable bushings; most will have to be replaced if wear is excessive.

To remove an idler arm, disconnect the arm from the steering linkage and unbolt it from the frame. Some idler arms have adjustable slots in the frame. Mark the idler arm prior to removing it to ensure proper positioning when reinstalling. These slots allow adjusting the centerlink to a level position.

Task A.3.5 Inspect, replace, and adjust tie-rods, tie-rod sleeves/adjusters, clamps, and tie-rod ends (sockets/bushings).

The tie-rods connect the center link to the steering knuckle on conventional steering systems. On rack and pinion steering, the tie-rods connect the steering knuckle to the steering gear. Conventional steering systems have inner and outer tie-rods coupled by a sleeve on both sides. The inner tie-rods connect to the center link. On rack and pinion designs, the inner tie-rods connect to the steering gear. Toe alignment adjusters are located on the tie-rod assembly. Toe must be checked after replacement of a tie-rod.

Worn tie-rods can cause front-end shimmy, loose steering, incorrect toe, and may cause tires to wear. Inspect the tie-rod for excessive up and down movement at its ball joint socket. Also check for movement where the tie-rod threads into the adjustment sleeve. Tie-rods with excessive movement will cause changes in toe, affect steering performance and should be replaced.

The tie-rod sleeves must be rotated to adjust front-wheel toe and center the steering wheel.

Replacing the inner tie-rod ends must be done carefully to prevent damage to the pinion teeth on rack and pinion steering. Firmly hold the rack while loosening the socket threads from the threads of the rack.

If the tie rod sleeve clamp is not positioned correctly before tightening, the clamp will not exert enough force to hold the threads together. The constant motion while the vehicle is in operation will wear the threads involved. The two pieces will pull apart, resulting in loss of steering control. On some vehicles, if the tie-rod sleeve clamp is not positioned with the proper orientation, the sleeve bolt could rub against a cross member or a suspension part or wear through a power steering hose.

Task A.3.6 Inspect and replace steering linkage damper(s).

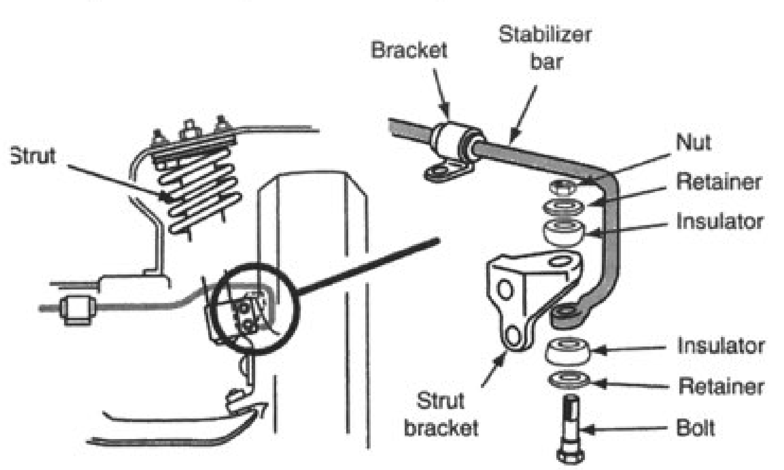
A worn steering damper may transmit road shock to the steering wheel.

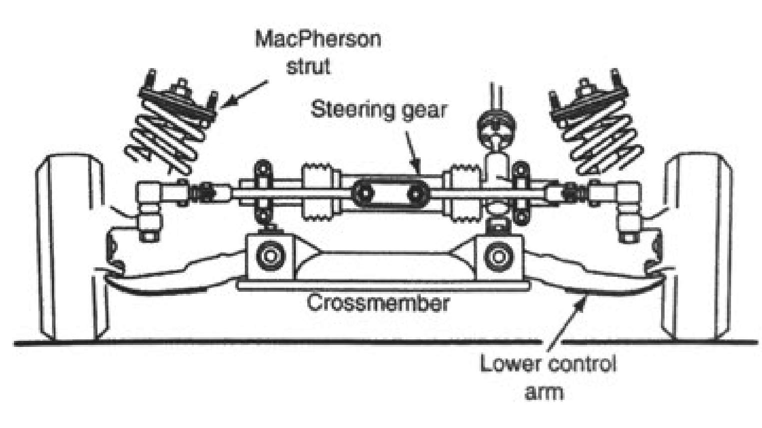
Steering linkage dampers (sometimes called steering linkage shock absorbers) are found on vehicles with conventional steering systems. The damper is secured on one end to the vehicle frame and is connected at the other end to the center link.

Steering linkage dampers are designed to help the steering and suspension systems keep road shock and tire vibrations under control. High-speed vibrations are mostly caused by tire and wheel imbalance. Steering linkage dampers work like a shock absorber and are checked the same way one would check for a bad shock.

B. Suspension Systems Diagnosis and Repair (13 Questions)

Task B.1 Front Suspensions (6 Questions)





Task B.1.1 Diagnose front suspension system noises, body sway/roll, and ride height concerns; determine needed repairs.

The most common front suspension complaints are noise, steering pull, irregular tire wear, excessive body roll, poor ride quality, and wheel shimmy. These problems are usually the result of worn bushings, worn ball joints, weak springs, faulty shock absorbers, defective tires, or worn steering linkage components. Broken springs or shocks will affect body roll, cause noise, and may affect steering ability. Leaking shocks will not affect vehicle ride height, but may cause poor ride quality.

Road testing the vehicle may reveal abnormal noises, pulling, or steering problems. Pushing down at each corner of the vehicle may uncover noises caused by worn shock bushings, broken springs, or worn suspension components. Wheel bearings and tires should not be overlooked as sources of problems. An out-of-round tire or loose wheel bearing may affect steering handling and ride quality. Also, do not overlook a faulty tire (concentricity) when diagnosing a pull to one side.

Check vehicle ride height on all vehicles and compare it to factory specifications. Incorrect ride height is usually caused by broken or worn springs. Some vehicles are equipped with adjustable torsion bars to correct ride height. Before adjusting the torsion bars, carefully inspect the suspension for worn or bent components. When replacing these bars, note they are designated left and right. Additionally, if reusing an old torsion bar, make index lines prior to removal so the bar can be more easily reinstalled.

Another common source for noise are worn ball joints and control arm bushings. As the vehicle travels over bumps, a squeak or groan can be heard. If the vehicle is equipped with a sway bar, inspect the sway bar links, link bushings, and frame mounts. Broken sway bar links will cause a cracking or banging noise and may cause excessive body roll.

Task B.1.2 Inspect and replace upper and lower control arms, bushings, and shafts.

Control arms allow for the upward and downward movement of the suspension and wheels. The control arms pivot at the ball joints and at the frame. Bushings at the frame allow for this movement. Inspect both lower and upper control arm bushings for wear. Removal of the control arms will be necessary to replace bushings. Some upper control arm designs incorporate a shaft and bushing assembly. This shaft must be carefully inspected and replaced if worn. Control arm bushings are usually replaced with the use of a press. After new bushings are installed, the fasteners are not tightened until the vehicle is on the ground; normal weight of the vehicle is on the suspension and sitting at its normal ride height.

Place safety stands under the lower control arms near the ball joints on most vehicles when replacing the upper control arms because the springs must be partially compressed. When replacing the lower control arms, the safety stands must support the vehicle by the frame so the arms can move down while the springs are removed. The safety stands must be placed in different positions under the vehicle when replacing upper control arms than when replacing lower control arms because of spring location.

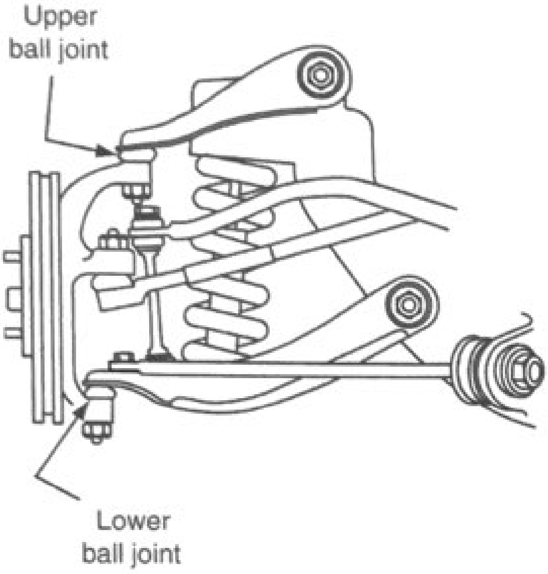
Task B.1.3 Inspect and replace rebound and jounce bumpers.

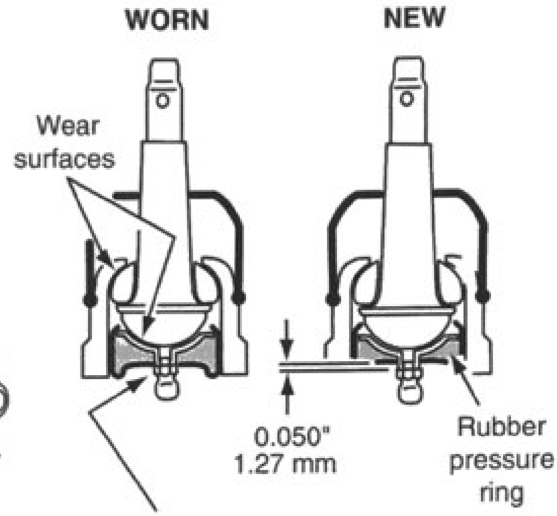
When the wheel hits a bump, the control arms pivot upward causing the spring and shock to compress. Rubber bumpers cushion the blow if the control arms reach their limit of travel. Jounce bumpers make contact if the suspension system is compressed too far. Rebound bumpers compress if the suspension is extended too far. Inspect the rebound or jounce bumpers for wear and cracks. In some cases, the bumper may actually be missing. The bumper may be located on the frame. Or, in the case of MacPherson strut, the bumper may be located on the strut rod under the protective boot. Worn bumpers can be caused by customer driving techniques, or by worn suspension components.

Task B.1.4 Inspect, adjust, and replace strut rods/radius arm (compression/tension), and bushings.

Worn strut rod bushings or a bent strut rod can cause changes in caster and/or toe. Worn bushings may result in the lower control arm moving rearward during braking.

Worn strut rod bushings can cause the vehicle to pull to the direction of the worn bushing every time the brakes are applied. Worn strut rod bushings can cause alignment problems. The adjustments available may not allow the desired specification to be reached if the bushings are worn.





Task B.1.5 Inspect and replace upper and lower ball joints (with or without wear indicators).

When a coil spring is mounted between the lower control arm and the chassis, position a jack under the lower control arm to unload the ball joints.

Do not place the safety stands under the frame to check for play in the load-carrying ball joint because the front spring tension would make it impossible to measure actual free play. Placing the safety stands under the lower arms on vehicles equipped with MacPherson struts would make ball joint free play impossible to measure because the ball joints would be supporting the weight of the front of the vehicle.

Ball joints carrying the majority of the vehicle weight are known as **load-carrying ball joints.** After correctly positioning the jack stand, check the ball joints for excessive wear. Consult the factory manual for specifications. Some ball joints are designed with a wear indicator at the threaded portion of the grease fitting. If the grease fitting shoulder is receded flush with the outer surface of the ball joint, replace the ball joint.

Worn ball joints can cause alignment problems, tire wear, hard steering, and wheel shimmy. On vehicles with upper and lower ball joints, the load-carrying ball joint usually wears first, but always inspect both. Ball joints must be properly unloaded to check for wear. When the coil spring is located between the lower control arm and the frame, position a jack under the lower control arm. Raise the jack until there is clearance between the floor and the tire. The ball joint is now unloaded. Wear is determined by the amount of axial (up and down) movement of the ball joints. Check the appropriate service manual for vehicle specifications. On MacPherson strut designs, raise the vehicle by the frame until the tire is off the ground and let the lower control hang down.

To replace a ball joint, make sure the control arm is properly supported, either on the control arm or frame, so that the ball joint is not under tension from the spring.

Remove the cotter pin (if equipped) and the ball joint retainer nut. Using a ball joint fork, separate the ball joint. Ball joints can be threaded, riveted, pressed, or bolted in place on the control arm. Use the correct tool, depending on the design. A new threaded ball joint must be torqued to specification. A riveted ball joint will be replaced with a new ball joint supplied with a hardware kit containing bolts, nuts, and washers. Torque the nuts or bolts accordingly. Tighten the ball joint retaining nut to specification and replace the cotter pin. If the hole for the cotter pin does not line up after torquing the nut, continue tightening until it does. Never loosen the nut to align the hole. Grease the ball joint if equipped with a grease fitting.

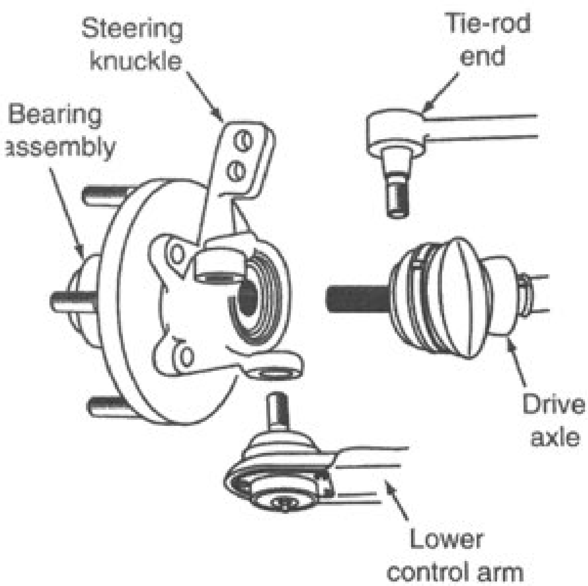
Task B.1.6 Inspect non-independent front axle assembly for bending, warpage, and misalignment.

Non-independent front axles are primarily used on 4WD trucks. It is a simple and strong design, requiring little maintenance. The non-independent front axle incorporates a solid front axle and is fitted with either leaf or coil springs. The solid axle does not turn with the wheels. The wheels turn by pivoting king pins or ball joints located on the spindle at the ends of the solid axle. Realignment is only necessary if parts are bent or damaged.

A disadvantage of the non-independent front axle is that it provides a rougher ride than independent front suspensions. The up-and-down movement of the front wheels tends to cause a tipping effect and imposes a twisting motion to the frame.

Although durable, a periodic inspection is required on non-independent front suspension. Inspect the axle for warpage, bending, twisting, and physical damage. Damage may not be obvious and looking for abnormal tire wear may sometimes identify a problem with the suspension. Misalignment of the axle will cause tracking problems and tire wear.

Inspect the king pins or ball joints for wear. If equipped with leaf springs, check for proper alignment of the spring to the front axle. If the vehicle design uses coil springs, check for worn or broken springs; check the radius arms and bushings for wear. If the radius arm bushings are badly worn, carefully inspect the radius arm bracket for signs of excessive wear at the point the radius arm passes through the bracket.



Task B.1.7 Inspect and replace front steering knuckle/spindle assemblies and steering arms.

Excessive tire squeal while cornering may be caused by improper toe-out on turns. This problem can be caused by a bent steering arm. Bent steering arms and steering knuckles or spindles show up in the alignment readings for toe-out on turns and in the steering axis inclination readings. Sometimes a technician can see rust flakes or disturbed metal at the bent section of the part. The parts named must be replaced if they are bent or otherwise damaged.

To remove the steering knuckle, raise the vehicle; remove the wheel and brake components. Support the suspension so that all the tension is removed from the ball joint(s). Disconnect the tie-rod end and separate the ball joints. On some MacPherson strut designs, the strut-to-knuckle bolts are used to adjust camber. Mark the position of the bolts so proper camber can be maintained during reinstallation.

To install the steering knuckle, reverse the procedure, torque all fasteners to specification, and check the front-wheel alignment. Road test the vehicle after installation to ensure proper brake performance and steering operation.

Task B.1.8 Inspect and replace front suspension system coil springs and spring insulators (silencers).

Coil springs are located between the axle (or control arm) and the frame or incorporated on a strut and shock assembly. The spring will compress to support the vehicle at specific ride height. The spring will also compress and rebound in a controlled manner as the vehicle travels over uneven roads. As the springs wear, ride height and ride quality will diminish. Inspect vehicle for signs of leaning to one side, which would indicate a weak or broken spring. Also, check the insulators at the top or bottom of the spring seats. On MacPherson strut design, check the upper strut mount and bearing. Always replace springs in pairs, either front or both rear.

To remove a coil spring, raise the vehicle off the ground and remove the wheel. Disconnect all steering and brake components necessary to gain access to the spring. Compress the spring using the appropriate spring compressor. Support the lower control arm and separate the lower ball joint. It may be necessary to remove the shock absorber. Lower the control arm and remove the spring. With the spring removed, inspect insulators and spring seats for wear. The new spring will have to be compressed to install it. Make sure the new spring is positioned correctly so that it sits correctly on the control arm and/or spring seat. Reinstall all components; drive the vehicle over a bumpy surface to settle the suspension then check the front-end alignment; and road test the vehicle. On MacPherson strut designs, the entire strut and shock assembly is removed as a unit from the vehicle. The spring is compressed and the upper spring mount is removed. Remove the spring and inspect the upper mount, strut bearing, and insulators.

Task B.1.9 Inspect and replace front suspension system leaf spring(s), leaf spring insulators (silencers), shackles, brackets, bushings, and mounts.

Removing and replacing front leaf springs are basic mechanical repair operations. Generally, leaf springs are replaced only when a leaf is broken or when they sag noticeably. Spring are usually replaced in pairs.

A leaf spring is mounted with a rubber bushing and bolt through the eye at one end and by rubber bushings and bolts on shackles at the other end. The shackles at one end of the spring let the spring length change as it flexes. If the spring were mounted directly to the frame at both ends, it would bind and eventually break.

Inspect shackles and bolts for damage and excessive wear. Inspect rubber bushings for wear, deterioration, and damage from grease and oil. Special removal and installation tools often make bushing replacement easier.

Task B.1.10 Inspect, replace, and adjust front suspension system torsion bars and mounts.

A torsion bar performs the same function as a coil or leaf spring. Its function is to support the vehicle weight and allow the wheels to follow the changes in the road surface and also absorb shock. The difference is, unlike a coil spring which compresses, the torsion bar uses a twisting action.

Removing and replacing torsion bars, like springs, are basic repair operations. Torsion bars also are generally replaced only when damaged. Unlike coil and leaf springs, torsion bar stiffness is adjustable on the vehicle; this is what establishes the ride height of the vehicle.

One end of the torsion bar is splined or clamped to a suspension control arm. The other end is secured in a bracket on the chassis. The chassis end of the torsion bar has a short arm and adjusting bolt to set ride height and bar stiffness. Checking the ride height and adjusting it if necessary is a basic part of wheel alignment service. Carmakers' ride height specifications and measurement points vary, so you should check manufacturers' instructions and specifications for this procedure.

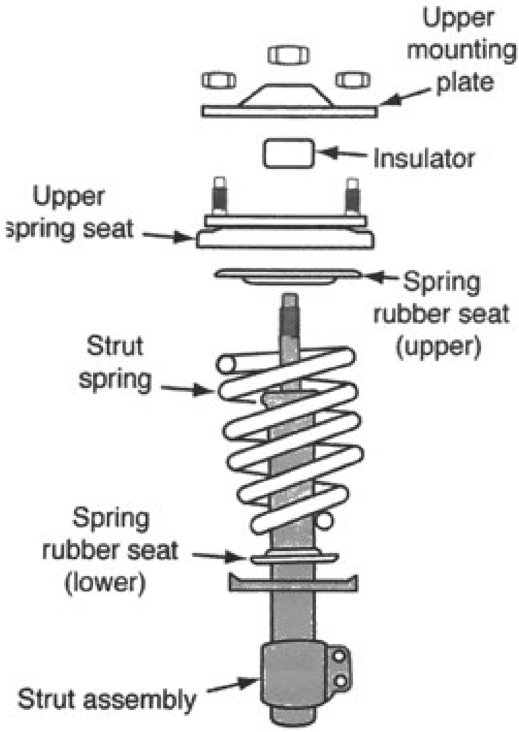
Some vehicles are equipped with torsion bars mounted transversely.

If the torsion bars are removed, make sure they are reinstalled on their original side. When replacing torsion bars, check for indicating marks: left and right.

Task B.1.11 Inspect and replace front stabilizer bar (sway bar) bushings, brackets, and links.

Stabilizer bars—also called anti-roll bars or sway bars—minimize body roll, or sway, during cornering. Stabilizer bars do not affect spring stiffness or vehicle spring rate, ride height, or shock absorber action. A stabilizer bar is mounted in brackets with bushings on the car underbody or frame. Links attach each end of the bar to the front or rear control arms or axle housing. During cornering, the bar and its links transfer vehicle loads from the inside to the outside of the suspension. This reduces the tendency of the outside suspension to lift and thus reduces body roll.

The rubber bushings on stabilizer bars and links tend to deteriorate over time and also can be damaged by grease and oil. Worn or damaged bushings should be replaced. Mounting bolts and link bolts may become loose and occasionally break. These should be tightened or replaced as necessary.



Task B.1.12 Inspect and replace front strut cartridge or assembly.

A new cartridge may be installed in some front struts with the strut installed in the vehicle. Other struts must be removed to allow cartridge installation. Prior to strut removal from the vehicle, remove the upper strut mounting nuts and the strut-to-steering knuckle bolts. Use a spring compressor to compress the spring before the spring is removed from the strut.

MacPherson struts are not only a suspension part, but also serve as a shock absorber and help control vehicle bounce. When replacing just the cartridge and not the outside housing, oil is left in the old housing to help transfer heat.

Task B.1.13 Inspect and replace front strut bearing and mount.

A defective upper strut mount may result in strut chatter while cornering, poor steering wheel return, and improper camber or caster angles on the front suspension.

The caster and camber adjuster plates would make noise if someone had left the bolts loose. The bearings and support plates support the weight of the front of the chassis, the engine, and the transaxle, and have to withstand the weight-shifting forces of braking and the rotating forces of steering the vehicle.

When the steering wheel wants to return to a position other than center, this is known as memory steer. Memory steering occurs when a steering component or bushing binds and prevents the steering gear from smoothly rotating back to center. That is why it is important that all steering components be tightened in their normal resting position. Possible causes for memory steering are: binding upper strut mounts, steering gear, linkage, ball joints, tie-rods, and idler arm. Removing the steering linkage from the steering knuckles can help isolate a binding component.

Sometimes the control valve in the steering gear fails and bypasses fluid into one side or the other of the boost cylinder piston causing the steering to want to turn itself to one side. To check this condition, raise the vehicle off the ground and start the engine. If the wheels want to turn to one side with the engine running, suspect a faulty control valve or steering gear.

Task B.2 Rear Suspensions (5 Questions)

Task B.2.1 Diagnose rear suspension system noises, body sway/roll, and ride height concerns; determine needed repairs.

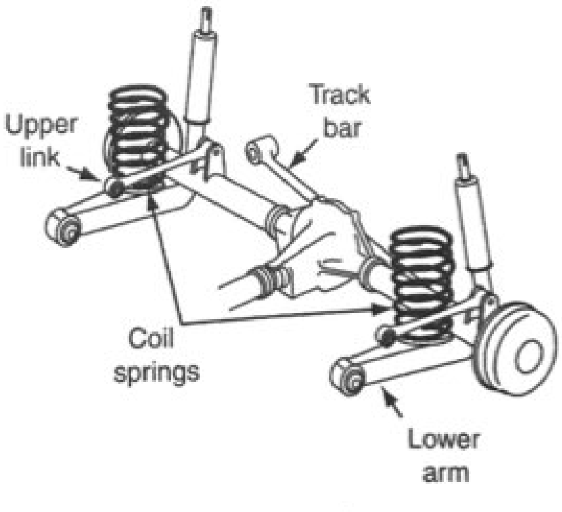
A squeaking noise in the rear suspension may be caused by suspension bushings, defective struts or shock absorbers, or broken springs or spring insulators. Harsh riding may be caused by reduced rear suspension ride height and defective struts or shock absorbers.

Excessive rear suspension oscillations may be caused by defective struts. Weak coil springs cause harsh riding and reduced ride height. Broken springs or spring insulators cause a rattling noise while driving on irregular road surfaces. Worn-out struts or shock absorbers result in chassis oscillation and harsh riding.

A broken spring leaf will cause the vehicle to lean toward the broken side. Missing insulators will cause creaking and squeaking noises, not rattles, as the suspension moves up and down. Worn shackle bushings or worn shackles will cause rattles when the vehicle is driven over road irregularities at low speeds. Broken center bolts will allow one side of the axle or housing to move forward or rearward. This will change the thrust angle.

Sway bars are not likely to cause vibrations. Coil springs with a high load rating could cause the vehicle to be too high in the rear.

If the rear strut cartridge is weak, the vehicle would bounce more than normal in the rear, but should not hit bottom going over speed bumps at low speeds. If the rear springs are weak, the chassis will hit bottom easily.



Task B.2.2 Inspect and replace rear suspension system coil springs and spring insulators (silencers).

When replacing rear coil springs, the old spring ends should be matched with the new springs. Matching the spring ends will ensure that the springs are installed correctly. Linear-rate springs or variable-rate springs may be used. Linear-rate springs have equal spacing between the coils and are available as heavy-duty springs for most applications. Variable-rate springs typically have coils spaced closer together at the top with more space between the coils at the bottom of the spring. Variable-rate springs provide automatic load adjustment while maintaining vehicle height. Again these springs are normally replaced in sets.

With the springs removed, inspect the spring insulators and spring seats. Replace worn or cracked insulators. Check for rusted or damaged spring seats. When installing the coil springs, make sure the spring is aligned properly in the spring seat. After the springs are installed, check vehicle ride height and road test the vehicle.

It may be necessary to compress the springs and to disconnect the shock absorber and other components to remove the springs.

Task B.2.3 Inspect and replace rear suspension system lateral links/arms (track bars), control (trailing) arms, stabilizer bars (sway bars), bushings, and mounts.

Different rear suspension designs utilize a variety of components. Generally, rear suspensions use coil springs, leaf springs, or MacPherson struts. When coil springs are used, systems of control arms, links, and/or track bars are used to maintain stability and alignment of the rear axle assembly. The control arms, lateral link, and track bar pivot points are insulated by rubber bushings. Inspect all bushings for wear and check all components for damage, twisting, or bending.

When replacing suspension bushings, it is important that the weight of the vehicle is on the bushings before tightening. Tighten all bushings at their normal standing ride height. Damage to the bushings will occur if they are not tightened in their normal resting position. This procedure applies to track bars and lateral arms also. It may be necessary to use a press or suitable tool to install rear suspension bushings. Only lubricate rubber bushings with an approved lubricant. Never lubricate with oil or grease.

Some rear suspensions have adjustable driveline (pinion) angles. Before installing control arms, check with the factory manual. On some vehicles, an eccentric washer on the control arm adjusts the driveline (pinion) angle.

The rear stabilizer bar (or sway bar) helps to control body roll on turns. The twisting action of the bar counteracts body sway on turns and holds the vehicle closer to a level riding position. Inspect the connecting links, link bushings, and mounting bushings for wear. If the sway bar is bent or damaged, replace it. As with other bushings, tighten only at their normal resting position.

Task B.2.4 Inspect and replace rear suspension system leaf spring(s), leaf spring insulators (silencers), shackles, brackets, bushings, and mounts.

Inspect the leaf springs, bushings, insulators, shackles, and mounts for wear and damage. The most common failure point on a rear leaf suspension is the spring bushings. Check the vehicle ride height to determine the condition of the springs. Leaf springs may sag or break over time. Carefully inspect each leaf in a multiple leaf design for broken leaves, worn insulators, and broken spring retaining clips. On older vehicles, inspect the frame for rot where the spring shackles and mounts bolt up to it. If the springs are not aligned properly with the rear axle or if the rear axle has shifted, check for a broken spring center bolt.

To remove the rear springs, raise the vehicle off the ground, support the rear axle assembly, and remove the wheels. Disconnect the shock absorbers; unbolt the rear shackles and the front mount from the frame. Remove the attaching U-bolts from the axle and remove the springs from the vehicle. Replace all worn bushings and other components, as required. After reinstalling the springs, tighten all bushings with the vehicle weight on the springs and at normal ride height.

Task B.2.5 Inspect and replace rear rebound and jounce bumpers.

The rear rebound and jounce bumpers serve the same purpose as in the front. When the wheel hits a bump, the control arms pivot upward causing the spring and shock to compress. Rubber bumpers cushion the blow, should the control arms reach their limit of travel. Inspect the rebound or jounce bumpers for wear and cracks. In some cases, the bumper may actually be missing.

Task B.2.6 Inspect and replace rear strut cartridge or assembly and upper mount assembly.

Rear struts are serviced similarly to front struts, except that rear struts do not have a steering knuckle. The coil spring on the strut must be compressed to separate it from the strut assembly. Some struts can be serviced by replacing an internal cartridge that contains the shock absorber. Others require replacement of the entire strut.

When reassembling the strut, be sure that the spring is seated securely in its mounting brackets. Inspect the upper mounting location on the car body. Replace any worn or damaged fasteners or other parts. If the body structure is damaged, more extensive repairs will be required.

Task B.2.7 Inspect non-independent rear axle assembly for bending, warpage, and misalignment.

A non-independent rear axle may be checked for bending, warpage, and misalignment by measuring the rear-wheel tracking. This operation may be performed with a track bar or computer wheel aligner with four-wheel capabilities. A track bar measures the position of the rear wheels in relation to the front wheels. A computer wheel aligner displays the thrust angle, which is the difference between the vehicle thrust line and geometric centerline of the vehicle. Rear axle offset may cause steering pull.

On vehicles with rear leaf springs, check the center bolt. If the center bolt is broken, the rear axle assembly may shift, causing misalignment. This would show up while performing a wheel alignment. The thrust angle and rear toe will not be correct. (Thrust angle and toe will be covered in the wheel alignment tasks.)

Task B.2.8 Inspect and replace rear ball joints and tie-rod/toe link assemblies.

Many ball joints have a wear indicator. In these ball joints, the shoulder of the grease fitting must extend a specific distance from the ball joint housing. If this distance is less than specified, replace the ball joint. There is no clearance between the grease fitting shoulder and the ball joint housing.

A worn ball joint may cause improper position of the lower end of the rear knuckle, wheel, and wheel. This action may result in improper rear-wheel camber.

If a rear-wheel tie-rod is longer than specified, the rear-wheel toe-out will be excessive. The length of the tie-rod determines the rear-wheel toe setting.

Rear load-carrying and non-load-carrying ball joints are tested like the front ball joints. Rear tie-rod ends are checked in the same manner as the front tie-rod ends. The rear ball joints and rear tie-rod ends usually last much longer than the front because the rear does not rotate and these components carry much less weight. Some rear ball joints and rear tie-rod ends have to be lubricated.

Task B.2.9 Inspect and replace rear knuckle/spindle assembly.

The steering knuckle or wheel spindle is the mounting point for the wheel and brake assemblies. The wheel rotates on the spindle shaft via a set of bearings. The steering knuckle/spindle is held in place by control arms and/or the suspension strut. To replace a knuckle/spindle, remove the wheel assembly and disconnect the ball joints, control arms, steering linkage, springs, and/or strut assembly from the spindle assembly. After reinstallation, align the wheels.

C. Related Suspension and Steering Service (2 Questions)

Task C.1 Inspect and replace shock absorbers, mounts, and bushings.

The function of the shock absorber is to control and dampen spring oscillations. Since shock absorbers are sealed units, no servicing is required. Inspect the shock bushings and mounts for wear. On most designs, the shock absorber will have to be replaced if the shock bushings are worn. Check for broken mounts and for physical damage to the shock.

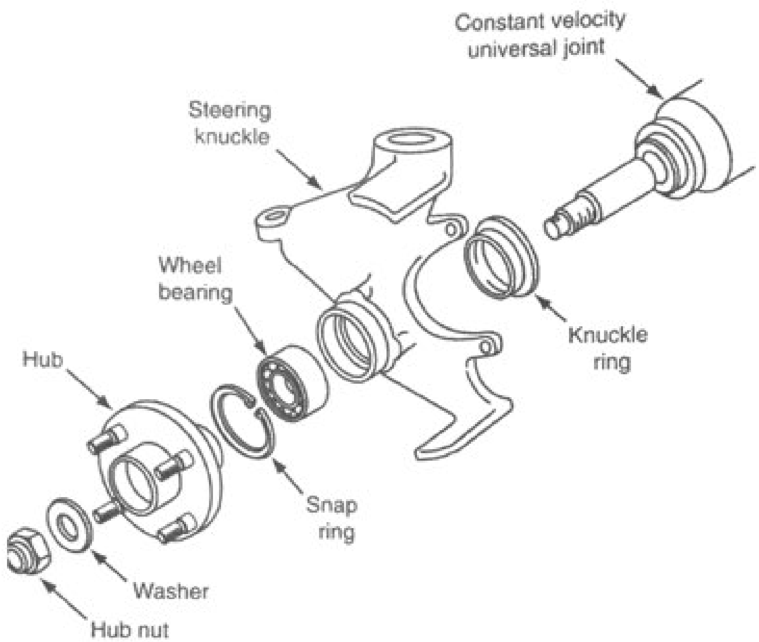
When one side of the bumper is pushed downward with considerable force and then released, the bumper should only complete one free upward bounce if the shock absorber or strut is satisfactory. More than one free upward bounce indicates defective shock absorbers, loose shock absorber mountings, or defective struts.

Shocks should be inspected for oil leakage. If oil is dripping from the shock, replace it. The procedure to remove a rear shock absorber is:

1. Lift the vehicle on a hoist and support the suspension on safety stands so the shock absorbers are not fully extended.
2. Disconnect the upper shock mounting nut and grommet.

3. Remove the lower shock mounting nut or bolts.
4. Remove the shock absorber.

When reinstalling, do not over-tighten the mounting hardware to the point that rubber mounting bushings expand past the washer.



Task C.2 Diagnose and service front and/or rear-wheel bearings.

The wheel bearings perform a major role in effective brake function and steering performance. There are two different types of wheel bearing designs used on modern automobiles: the adjustable tapered roller bearing and the non-adjustable sealed roller or ball bearing.

Worn wheel bearings can cause a growling noise and vibration when the vehicle is driven. Checking for loose or worn wheel bearings should always be part of a complete steering/suspension inspection. A worn or improper wheel bearing adjustment can cause poor brake performance, poor steering, and rapid wheel bearing wear.

Tapered wheel bearings can be disassembled, cleaned, re-greased, and adjusted. Sealed roller or ball bearing wheel bearings cannot be serviced and are replaced as a unit.

Tapered roller bearings are generally used on non-drive axles. The wheel bearings are mounted between a hub and a fixed spindle. To gain access to tapered wheel bearings, remove the wheel, brake rotor or drum, dust cap, cotter pin, spindle nut, and the outer wheel bearing. Remove the hub/rotor or hub/drum assembly. Pry the wheel bearing seal and remove the inner wheel bearing. Thoroughly clean the wheel bearing, hub assembly, spindle shaft, and races. Carefully inspect the wheel bearings, spindle, and races for signs of wear. Discard bearings showing any signs of wear, chipping, galling, or discoloration from overheating. If the race is loose in the hub, the hub is worn and the hub must be replaced. Repack the wheel bearings with high temperature grease. Never repack a wheel bearing without first removing all the old grease. Insert the inner bearing into the hub and lightly lubricate the new wheel seal with grease. Tap the seal in place using a seal driver. Carefully install the hub/rotor or hub/drum assembly onto the spindle. Install the outer wheel bearing, washer, and spindle nut.

If the wheel bearings need to be replaced, it will be necessary to replace the bearing races also. Remove the bearing race from the hub using a bearing race installer. If using a drift punch, tap the races a little at a time, moving the punch around the race to avoid cocking. Use a soft steel drift, or a brass drift, never a hardened punch. When installing the new race, drive the race in until the sound changes, becomes a dull thud, this indicates the race is fully seated.

It is very important to properly adjust tapered wheel bearings. Always check the manufacturer's recommended procedure for the specific vehicle being serviced. There are two widely used methods for adjusting wheel bearings: the torque wrench method and the dial indicator method.

In the torque wrench method, rotate the wheel in the direction of tightening while the spindle nut is tightened to the specified torque. This initial torque setting seats the bearings in the races. The nut is then loosened until it can be rotated by hand. The nut is then re-torqued to a lower specified value. Back the nut, if necessary, to install the cotter pin, and lightly tap on the dust cap.

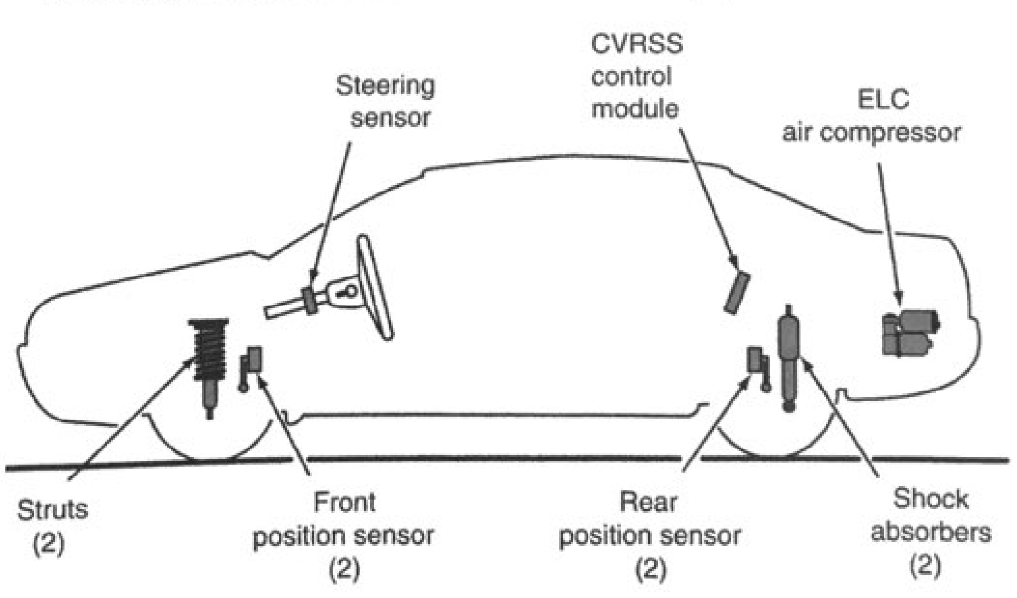
To adjust the wheel bearings using the dial indicator method, start by tightening the spindle nut while spinning the wheel, to full seat the bearings. Loosen the spindle nut until it can be rotated by hand. Mount a dial indicator so the indicator point makes contact to the machined outside face of the hub. Firmly grasp the sides of the rotor or tire and pull in and out. Adjust the spindle nut until the end play is within manufacturer's specification. Typical end play ranges from .001 inch to .005 inch. Install the cotter pin and dust cap.

Sealed ball and roller bearings are not serviceable and must be replaced when they are worn, defective, or have damaged grease seals. Removing this type of bearing involves pressing the bearing from the hub of the spindle or knuckle assembly. Carefully inspect the bearing, hub, and spindle assembly for wear. Press the new bearing into the spindle/knuckle assembly and torque the axle nut following the manufacturer's procedure. Torquing this nut seats the drive axle in the hub. Note, some bearings are now a self-contained unit and the assembly bolts into the steering knuckle.

Task C.3 Diagnose, inspect, adjust, repair, or replace components (including sensors, switches, and actuators) of electronically controlled suspension systems (including primary and supplemental air suspension and ride control systems.

Automatic level control systems are designed to maintain correct vehicle ride height under different load changes. Level control systems use air pressure that is pumped into air shocks or air bag springs in response to different load changes. Air pressure is developed by an electrically operated pump. Some systems use a dryer assembly to absorb moisture from the system. This reduces the chance of corrosion damage to internal components. Some vehicles have a manual shutoff switch to disable the automatic level control system. On these vehicles, the switch must be turned off whenever the vehicle is raised off the ground from the frame with the wheels hanging.

Once the air suspension system has been shut down for an hour, it becomes inactive. If there are leaks, the vehicle ride height will decrease when the vehicle is parked and not in use. It is normal for an air suspension system to drop a little overnight, especially when there is a significant temperature change. If the system is functioning properly, the vehicle will level itself soon after startup. Most air suspension systems, both primary and supplemental, are automatic and have height-level sensors, air control solenoids, relays, an electric air pump, and a module to make the system work. Most modern systems will store fault codes to help with diagnosis. Some systems have a function test that allows each corner of the vehicle to be raised and lowered to verify operation.



Use a scan tool for diagnosing the electronic suspension. Refer to the scan tool manufacturer's instructions for specific information.

An inspection of an automatic level control system should include: the compressor, height sensors, hoses, hose connections, air shocks (or air struts), electrical connectors, relays, solenoids, wire harness, electrical components, dryer, and pressure regulator. Consult the factory manuals for detailed information on various systems.

The **computerized ride control** system is another automatic suspension design. These suspensions are computer controlled and can adapt to different road conditions and driving situations. Hydraulic pressure is redirected and controlled by the use of actuators within the shock absorber or strut. In this way, the suspension can be altered from a soft ride to a stiffer ride. Some systems will allow the driver to select the type of ride desired for the particular road conditions. For example, a firmer, more controlled setting would be more desirable on a winding road. For highway cruising, a softer mode would be more applicable. On many systems, the computer may override any pre-set modes. If the vehicle is under a hard braking situation, the controller will stiffen up the front shocks to help maintain vehicle control. The same will be true under heavy acceleration. The controller will stiffen the rear shocks to minimize rear-end squatting. When the driver turns hard into a turn, the controller will stiffen the outside shocks and reduce body roll.

Typical computerized ride control systems incorporate a control module, brake sensors, steering sensors, acceleration sensors, mode select switch, actuators, and height sensors. Diagnosing a computerized suspension system varies for different manufacturers. It will be necessary to follow the diagnostic procedures in the appropriate service manual. If the computer recognizes a problem within the system, it will alert the driver by illuminating a warning light on the dashboard. A trouble code may be stored in the memory of the computer, which will aid in the diagnostic process.

Task C.4 Inspect and repair front and/or rear cradle (crossmember/subframe) mountings, bushings, brackets, and bolts.

On unibody vehicles, a subframe is used to help support and locate the drivetrain. On vehicles with a frame and some unibody vehicles, a cross member is used to support the engine and/or transmission. Proper alignment of the drivetrain is critical to the handling of the vehicle and the operation of many systems of the vehicle. As an example, if the cross member or subframe is not secure to the vehicle or if the mounting's bushings are worn, the driver may experience shifting problems due to the misalignment of the shift linkage.

When servicing these units, relieve the weight of the engine and/or transmission before performing any service. This is often done by securing the engine on a hoist.

Task C.5 Diagnose, inspect, adjust, repair, or replace components (including sensors, switches, and actuators) of electronically controlled steering systems; initialize system as required.

The most common electronically controlled steering employs a conventional steering pump and utilizes an electrically operated pressure control assembly on the pump or steering gear. Information from various sensors such as vehicle speed sensor and steering shaft speed sensor are sent to the controller. Steering effort and steering performance is greatly improved. If the controller detects a fault in the system, the steering usually returns to conventional steering assist. A warning light will illuminate should a fault occur; a trouble code may be stored in the computer, depending on the system.

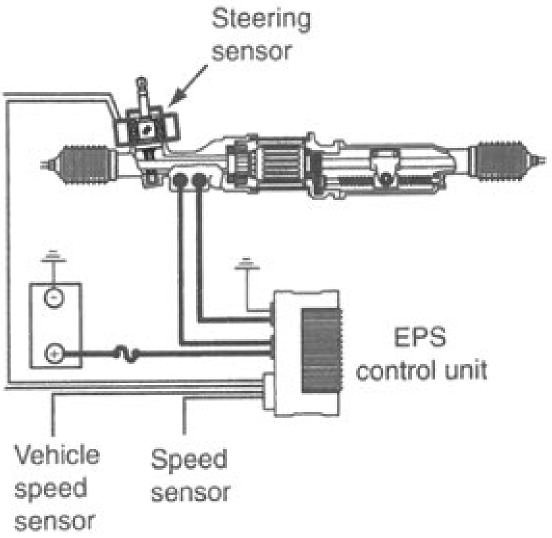
Two new electronically controlled steering system designs are the electro-hydraulic and all-electric steering. These systems are fully computerized and are part of total vehicle management control.

An electro-hydraulic steering system uses a pump driven by an electric motor. The controller will vary pump pressure and flow resulting in varying steering efforts for different driving conditions. The pump can be regulated to run at low speed with low pressure for straight-ahead driving, where full power assist is not needed. During a parking maneuver, pump output will increase, providing increased steering assist where it is needed the most. By controlling the steering assist, steering performance is enhanced and energy is saved.

All electric steering systems use an electric motor that is attached to and operates the steering linkage, steering gear, or steering rack. A variety of motor designs and gear drives are possible, depending on the vehicle. As with the electro-hydraulic steering system, steering effort can be controlled, reducing steering assist while driving straight ahead and increasing steering assist at low speeds.

Typical electronic steering systems incorporate a microprocessor, steering sensor, electric motor, vehicle speed sensor, differential sensor, and other sensors. Inputs from the sensors are sent to the steering control unit and evaluated. Depending on the input from various sensors, the computer will send out the appropriate command to the power unit, which will then control the steering motor. Steering assist will change as the vehicle increases speed, decreases speed, and when the vehicle is turning left or right.

Diagnosing electronically controlled steering starts with a complete visual inspection of the unit, motor, and sensors. Electronic steering systems have the capability of storing diagnostic trouble codes, which will help in analyzing a fault within the system. If a problem does occur, the control unit will shut down the system and employ a fail-safe mode. Steering will revert to manual mode. A warning light will illuminate on the dash panel to alert the driver. Follow the appropriate service manual for diagnostic procedures and for obtaining trouble codes.



Task C.6 Diagnose, inspect, repair, or replace components of power steering idle speed compensation systems.

Power steering pumps, as in other accessories, put a load on the engine. When the wheels are turned during a parking maneuver and held against the wheel stop, the load increases significantly. Most newer computerized vehicles use a sensor that sends a message to the PCM when power steering pressure is high. The computer will increase the idle to compensate for the load from the power steering pump and prevent stalling.

D. Wheel Alignment Diagnosis, Adjustment, and Repair (12 Questions)

Task D.1 Diagnose vehicle wander, drift, pull, hard steering, bump steer (toe curve), memory steer, torque steer, and steering return concerns; determine needed repairs.

Wheel alignment is the process of measuring and correcting steering and suspension angles. Proper wheel alignment is desired in order to control the vehicle in a safe and predictable manner. Incorrect wheel alignment can cause hard steering, premature tire wear, pulling to one side, wandering, and decreased steering performance. Before a wheel alignment is performed, a complete inspection should be done on the suspension and steering system. Worn steering components or bent suspension parts will prevent the vehicle from being aligned properly. Sagging springs, broken springs, worn wheel bearings, or loose wheel bearings will also affect the wheel alignment.

The first step in the alignment process starts with a road test. Take notice of pulling, wandering, wheel shimmy, and any other steering problems. Does the problem seem to change during braking? Does the vehicle track well in a straight line but feel "loose" when turning? Does it turn better in one direction than the other? These are all items you should be taking in when you are driving the vehicle. Develop a test route and drive it each time to duplicate all kinds of driving conditions and turns. Check and adjust tire pressure while the vehicle is at the correct ride height. Setting the caster, camber, and toe without correcting ride height may not cure tire wear and handling problems. Incorrect ride height in front-wheel drive vehicles may cause vibrations, especially during acceleration. All steering linkage parts, except the idler arm (in some cases), should have zero free play and should be replaced if any looseness is felt or measured during inspection. Incorrect idler arm adjustment can cause bump steer.

In all vehicles, the rear alignment must be correct before any corrections are made to the front. For vehicles with rear-wheel steering, the rear steering system must remain in its centered position while the front adjustments are being checked and adjusted.

Term	Description	Possible Causes
Wander, Drift, and Pull	These terms really describe varying degrees of the same thing. Wander describes a condition in which the vehicle will not travel in a straight line over time. It is usually caused by incorrect settings of caster or toe out. The vehicle will "wander" around the road. Drift is more of a directional wander when a vehicle has a tendency to wander more in one direction. Pull is when a vehicle really leads in a direction as it is moving. Pull may be alignment-related and happens statically (at all times), or may be an intermittent condition that occurs during braking on particular road surfaces. Sometimes switching the tires from side-to-side can help in diagnosing a pull to one side caused by a tire. If the pull goes away or pulls to the other side after switching tires, the problem is with the tires, not the alignment. Since the steering pulls to the side with the least positive caster, excessive positive caster on the left front wheel may cause steering pull to the right. Low tire pressure on the right front will cause the vehicle to pull to the right. Excessive front-wheel toe-in causes feathered tire wear; this problem does not affect steering pull. The steering tends to pull to the side with the most positive camber.	Tire wear Tire cord damage Tire design Inadequate caster setting Incorrect side-to-side caster setting Excessive front or rear toe-out Worn suspension bushings Loose or worn steering components Bent steering/ suspension components Loose wheel bearings
Torque Steer	This condition is caused by uneven application of engine power to the wheels. In front-wheel-drive vehicles, one drive axle is usually shorter than the other. Under acceleration, the vehicle will tend to steer toward the shorter axle. Torque steer can occur in rear-wheel drive and 4WD vehicles when either control arm bushings or spring eye bushings wear and deflect. Torque steer is associated with acceleration or the application of power.	Damaged leaf spring bushings Damaged leaf spring U-bolts Thrust angle problems Incorrect caster/toe settings Worn sway bar bushings (some FWD) Worn radius arm bushings (some FWD) Worn control arm bushings

(Continued)

Term	Description	Possible Causes
Bump Steer (Toe Curve)	This is a dramatic change in the toe settings of the vehicle on one or both wheels when the vehicle encounters a bump or sometimes in the rebound from a bump. The vehicle will demonstrate everything from a small squirm on the road to a dart into the next lane. Bump steer is usually the result of a damaged component in the steering. For example: if a tie-rod is bent on only one side, the toe on that side may change dramatically on a bump. Watch for bump steer on vehicles with altered or sagged ride-height.	Loose rack bushings Loose steering gear Bent steering rod(s) Loose inner tie-rods Sagged springs allowing excessive travel or moving steering out of the designed toe curve.
Memory Steer (hard steering and poor steering return)	This is a term for the steering wheel failing to return to center after a turn. Memory steer can be caused by steering or suspension components that are binding or worn. Many older trucks demonstrated memory steer when their king pins or spindle ball joints were not lubricated regularly. To determine if the problem is in the steering system or the suspension, disconnect the tie-rods from the steering knuckles and manually turn the suspension to isolate the binding component. The failure is almost always in a load-carrying component.	Upper strut bearing failure Seized/dry ball joints or king pins Inadequate positive caster Steering rack or gear adjustment too tight Power steering control valve failure Steering column bearing failure

Memory steering occurs when a steering component or bushing binds and prevents the steering gear from smoothly rotating back to center. That is why it is important that all steering components be tightened in their normal resting position. Possible causes for memory steering are: binding upper strut mounts, steering gear, linkage, ball joints, tie-rods, and idler arm. Removing the steering linkage from the steering knuckles can help in isolating a binding component.

Sometimes the control valve in the steering gear fails and bypasses fluid into one side or the other of the boost cylinder piston causing the steering to want to turn itself to one side. To check this condition, raise the vehicle off the ground and start the engine. If the wheels want to turn to one side with the engine running, suspect a faulty control valve or steering gear.

Task D.2 Measure vehicle ride height; determine needed repairs.

Vehicle ride height is an important specification and must be checked before the alignment is performed. Ride height is usually adjustable on a vehicle with torsion bars.

Ride height can vary significantly on a single model of a light truck with various spring and wheel-and-tire combinations. As ride height varies, so does the front camber angle. Many trucks have different camber specifications for different ride heights. Most truck manufacturers publish tables of varying ride height specifications that should be checked during the alignment operation.

Ride height measurement points vary from one vehicle to another. Some are measured between the lower control arm and the ground; still others have the technician measure between two points of the vehicle chassis. Others are measured between a point on the fender well or under body and ground. Always verify the vehicle manufacturer's measurement points, as well as the specifications.

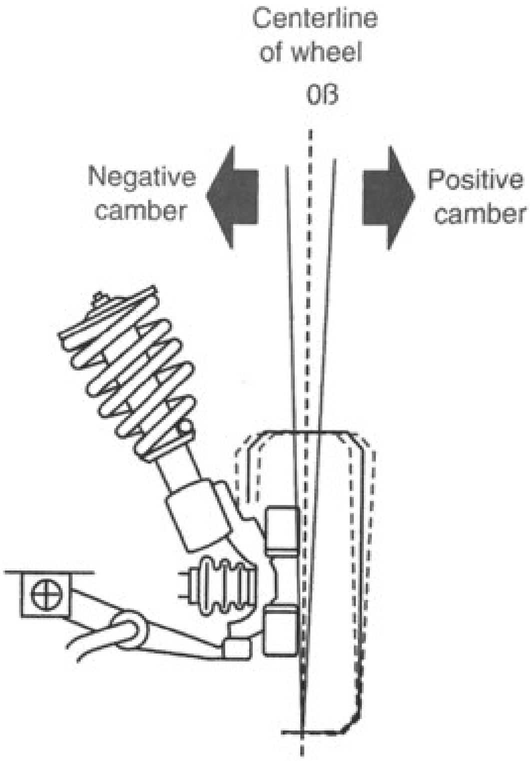
If ride height is out of limits on a vehicle with coil or leaf springs, the springs or other suspension parts may require replacement. Springs are normally replaced in sets.

Most vehicle manufacturers call for wheel alignment adjustments with the vehicle unloaded and at a specified ride height. Some carmakers, however, specify precise weight loads to be placed in a car during alignment. Trucks are often aligned with specified loads.

Task D.3 Measure front- and rear-wheel camber; determine needed repairs.

Camber is the outward or inward tilt of the wheel as viewed from the top of the tire. The more inward the top of the wheel is from true vertical, the more negative the camber. The more outward the wheel is from true vertical, the more positive the camber. Incorrect camber may cause increased road shock and pulling to one side. Also, incorrect camber can lead to rapid tire wear.

If camber is not adjustable, inspect the struts, suspension, and steering system for bent components. Replace damaged or bent components as needed, and recheck camber angles.



Task D.4 Adjust front- and/or rear-wheel camber on suspension systems with a camber adjustment.

Vehicle manufacturers provide many different ways to adjust front and rear camber:

- Shims may be placed between various suspension components and the frame. (Shims are usually used between control arm pivot shafts and their mounting brackets on the frame.)
- An eccentric cam lobe may be turned to move the control arm pivot point inward or outward on the chassis.
- Sleeves may be adjusted on control arm linkage.
- Strut mounts may be moved.

Vehicle manufacturers publish wheel alignment specifications annually. Most computerized alignment equipment contains an on-board database of specifications and adjustment instructions. Typically a vehicle will have a positive camber setting, and cross camber (side-to-side camber) should not vary more than 0.5 degrees.

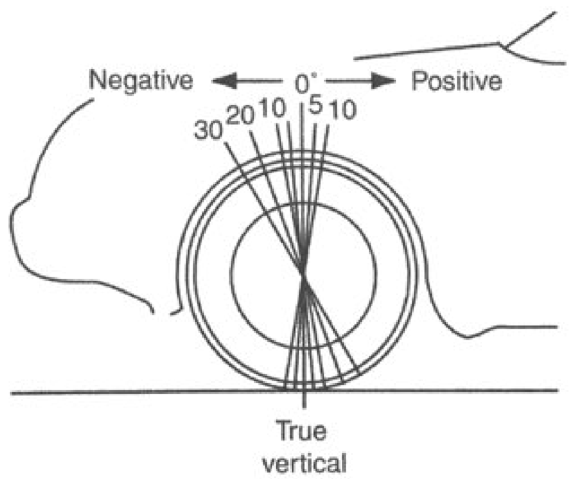
Some vehicles have slightly more positive camber on the left front wheel than on the right to minimize vehicle pull caused by the crown of the road. More often, however, road crown compensation is done with slightly different caster angles.

Front-wheel camber and caster are adjusted simultaneously on some vehicles that provide adjustment. Before adjusting camber and caster, jounce the vehicle to relieve any binding or stress on suspension parts and let it settle at its normal ride height. When either angle is adjusted, the other should be checked because changing one will affect the other. The front-wheel toe angle is adjusted after caster and camber adjustments are done. Toe will not change caster and camber settings.

Task D.5 Measure caster; determine needed repairs.

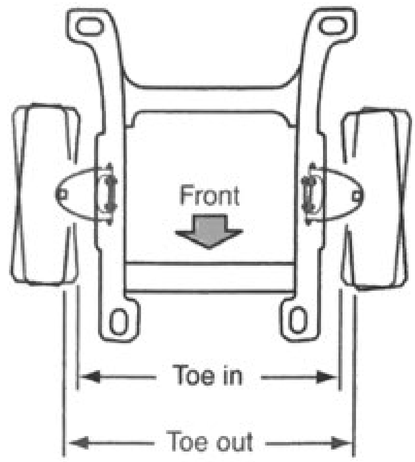
Caster is the tilting of the spindle support centerline from true vertical. Measuring the position of the lower ball joint in relation to the upper ball joint, or the top of the MacPherson strut, determines the caster angle. The spindle support centerline is an imaginary line drawn through the center of the upper ball joint and lower ball joint, or the ball joint and the center of the upper strut mount on a MacPherson strut design. If the lower ball joint is positioned more forward than the upper ball joint, the caster angle is positive. If the lower ball joint is set more rearward than the upper ball joint, the caster angle is negative. On a MacPherson strut design, if the ball joint is positioned more forward than the center of the upper strut mount, the caster angle is positive.

Caster helps improve steering effort, high-speed stability, and steering wheel returnability. Correct caster angles will keep the vehicle traveling in a straight line going forward. On most vehicles, caster is set positive and is usually set at the same degree on both sides or with slightly more on the right side of the vehicle to compensate for the drainage crown built into most roads. Too much positive caster will cause hard (heavy) steering, road shock, and wheel shimmy. Caster set too negative will cause wandering. Caster usually should not vary more than 0.5 degrees from one side to the other. If caster is not within specification and no adjustments are provided, inspect the suspension and steering for bent or damaged components. Also, if the vehicle was involved in a collision, check for frame damage. A vehicle will tend to pull to the side that has the least positive caster. Incorrect caster **will not** cause tire wear.



Task D.6 Adjust caster on suspension systems with a caster adjustment.

For vehicles with adjustable caster, consult the service manual for specifications and procedures. Before making caster adjustments, perform a complete steering and suspension inspection. On some vehicles, the caster is adjusted by moving the lower strut rod. By lengthening or shorting the lower strut rod, caster can be brought into specification. On some MacPherson strut vehicles, loosening the upper strut mount and sliding it forward or backward adjusts caster. Vehicles with SLA (short/long arm suspension) often provide caster adjustments. Shimming or sliding the upper control arm will adjust caster. Some upper control arms are designed with eccentric cams that are rotated to adjust caster. Adjusting caster by moving the upper control arm can also incorporate camber adjustment. Some light trucks have an offset upper ball joint bushing that will provide caster adjustment. Bushings come in different sizes that correspond to different degree changes in caster. For example, if you want to change caster 0.5-degrees positive and the bushing in the original upper ball joint bushing is 0 degrees, remove the old bushing and install a 0.5-degree bushing. Make sure the bushing is inserted in the correct position to achieve positive 0.5 degrees. Consult the service manual for procedures on removing and installing the bushing. There are other methods of adjusting caster. Check the service manual for a specific vehicle.



Task D.7 Measure and adjust front-wheel toe.

Setting front toe is performed after camber, caster (front and rear), and rear toe have been checked and /or adjusted. Turn the steering wheel from side-to-side, center it, and then lock it in place using the appropriate tool. If the vehicle is equipped with power steering, have the engine running when centering the steering wheel. Measure front toe and check factory specifications. Front toe is adjusted by turning the toe rods until correct toe is attained. On conventional steering systems, loosen the tie-rod sleeve clamps and turn the sleeve to change toe. For rack and pinion steering, loosen the locknuts and rotate the inner tie-rods. Some vehicles only have one adjusting tie-rod. On these vehicles, the steering wheel is not locked in place. Follow recommended procedures for adjusting toe and centering the steering wheel on these vehicles. On vehicles with adjusting sleeves, make sure the adjusting clamps are re-tightened in the correct position so as not to interfere with other steering linkage or other components when the wheels are turned. After toe has been adjusted, road test the vehicle. The steering wheel should be straight with the wheels in the straight-ahead position.

Task D.8 Center steering wheel.

If front toe is set correctly, the steering wheel should be centered correctly. If the steering wheel is not straight, it may be necessary to recheck toe. Remember to bounce the suspension and to idle vehicles with power steering after toe adjustments to be sure they are correct. Also, make sure the vehicle is tracking correctly. A misaligned rear suspension or twisted frame will affect steering wheel centering. If the steering is not straight, be sure to recheck the rear settings—particularly thrust line.

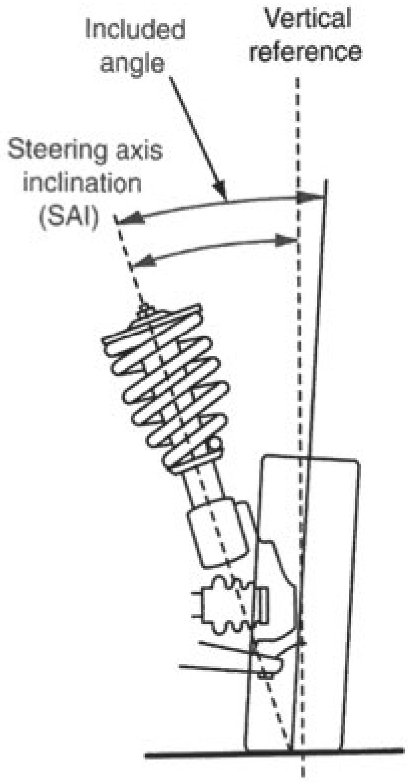
Task D.9 Measure toe-out on turns (turning radius/angle); determine needed repairs.

The turning radius of the wheel on the inside of the turn is several degrees more than the turning radius on the outside of the turn. When the turning radius is not within specifications, a steering arm may be bent.

Turn the front of the right wheel inward 20 degrees and read the turn table indicator on the left wheel. It should be slightly more than 20 degrees. Perform the same procedure by turning the front of the left wheel inward 20 degrees. Compare these readings and check the service manual for exact specifications. Turning radius angles (toe-out turns) are built into the steering arm design. If the angles are not correct, check the steering arms, steering knuckles, and suspension for bent or damaged components.

Task D.10 Measure SAI/KPI (steering axis inclination/king pin inclination); determine needed repairs.

Steering axis inclination (SAI) is not adjustable, but should be measured and used to analyze handling problems or tire wear problems. Before checking steering angle inclination, completely inspect steering and suspension along with a wheel alignment. SAI is the imaginary line formed by the inward tilt of the upper ball joint or strut mount. The angle is measured in degrees from true vertical. If SAI is incorrect, check for a bent component or frame.



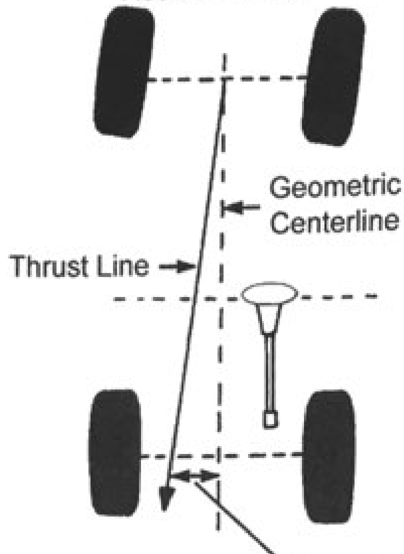
Task D.11 Measure included angle; determine needed repairs.

The **included angle** is determined by adding the camber and steering angle inclination together on any one wheel. A large difference from side-to-side is an indication of a bent suspension component, steering knuckle, or even frame damage. The included angle is not adjustable and is used to determine steering or tire wear problems.

Task D.12 Measure rear-wheel toe; determine needed repairs or adjustments.

Rear toe is usually adjusted by eccentric cams or threaded rods. On some models, rear toe is adjusted by loosening a lock bolt and moving the suspension until the correct toe is attained. Shims installed between the rear axle flange and the wheel bearing can be used to adjust toe when no adjusters are provided. Check with shim manufacturers for specific procedures and application. On models with no adjustments, inspect the rear suspension for misaligned, bent, or damaged components.

On vehicles with **four-wheel steering**, check the appropriate service manual for specific procedures. Usually a special tool is needed to lock the rear steering gear in place while rear toe and rear camber adjustments are made. The tool is removed when the front camber and caster is set, but re-installed to adjust front toe.



Task D.13 Measure thrust angle; determine needed repairs or adjustments.

Imagine that the vehicle has an exact geometric centerline that runs through the center of it. Now imagine a live axle like you would find in rear-wheel drive vehicles with both rear wheels running exactly parallel to the geometric centerline of the vehicle. This angle of the tires is the thrust angle.

As long as the angle is the same as or very close to the geometric centerline of the vehicle, it will track straight down the road. If the toe is pointed out on one side and in on the other, the vehicle will go in that direction when moving. You have probably seen a vehicle that appears to be going down the road with the rear out to one side or the other of the front wheels. This is often called "dog tracking" and is really a thrust angle problem. Remember that in a rear-wheel drive application, the rear wheels steer the car and the front wheels correct for the rear. In front-wheel drive applications, a vehicle can still "dog track," but it will not normally be perceived by the driver until the rear tires start to wear out. In most situations, one tire will wear more than the other.

Thrust line issues can be caused by only one rear tire being significantly toed in or out. The triangulation of both rear toe readings is used to find the thrust line. Take the point of the triangle, whether it is ahead or behind the vehicle; where it points away from the vehicle centerline is the thrust angle. Causes of thrust angle problems on front-wheel drive or independent rear-end vehicles include: incorrect toe settings; bent rear components like knuckles, control arms, and radius arms; bent or shifted rear suspension cradles; or frame damage. Thrust angle problems on rear-wheel drive live axle vehicles may be caused by: worn spring eye bushings; broken leaf springs or broken leaf spring center bolts; loose or damaged leaf spring U-bolts; worn control arm bushings; bent frame or suspension mounting points; or a bent axle housing.

Task D.14 Measure front wheelbase setback/offset; determine needed repairs or adjustments.

Setback occurs when one front wheel is rearward in relation to the opposite front wheel. Front wheelbase setback is usually caused by collision damage. In other cases, it is designed into the vehicle.

It is possible for caster and camber adjustments to be within specification while the setback is excessive. In that case, the vehicle will pull to the side with the most setback because that side has a shorter wheelbase.

Task D.15 Check front and/or rear cradle (crossmember/subframe) alignment; determine needed repairs or adjustments.

The front cradle may be measured in various locations to verify a bent condition. Some cradles have an alignment hole that must be aligned with a matching hole in the chassis.

The subframe is a critical part of the vehicle suspension and affects the steering. It must be properly centered in its designated location before the mounting bolts are tightened. Vehicle collisions can cause damage to the subframe, which will show up as excessive setback. Subframes must be centered properly with the chassis before the bolts are torqued.

E. Wheel and Tire Diagnosis and Service (5 Questions)

Task E.1 Diagnose tire wear patterns; determine needed repairs.

Feathered tire wear may be caused by improper toe adjustment. Wear on one side of the tire tread usually indicates an improper camber setting. Cupped tread wear may indicate improper wheel balance, worn shocks, or worn suspension components.

Tires wear excessively because the tire tread is not contacting the road surface properly. Alignment adjustments correct most of that problem. Normally, vehicles are aligned with no extra loads in the cargo area or passenger compartment. There are special circumstances, like large drivers or drivers who do not distribute cargo weight properly, that require the vehicle be similarly loaded while the alignment is made.

Task E.2 Inspect tire condition, size, and application (load and speed ratings).

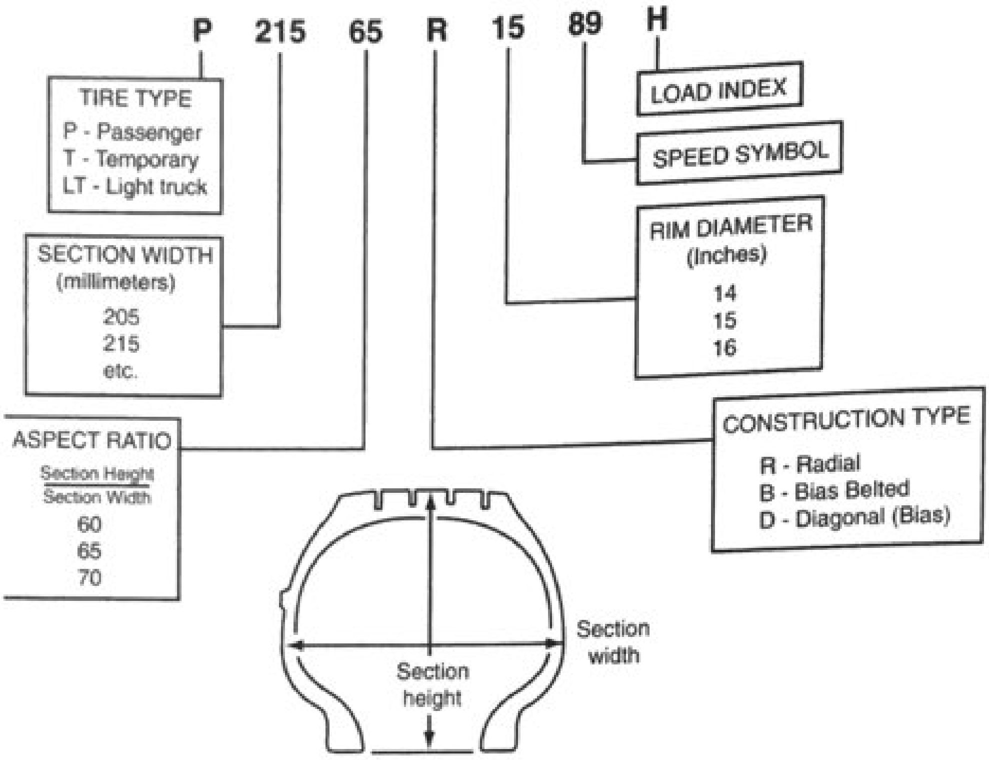
Tires play a vital role in braking performance, handling ability, and ride quality. Defective tires, improper inflation, or installing the wrong tires can have a negative effect on overall vehicle steering and handling.

Different vehicles with different suspensions are designed to be driven with a specific tire construction, tire size, and tire pressure. The load exerted on the tires of a pick-up truck used for hauling heavy cargo is quite different than a small compact sedan. Using the wrong tires on a vehicle or not inflating the tires correctly can cause serious results, tire damage, and may affect steering ability. Always install the correct tire size and adjust pressure to specification. Tire load information labels can generally be found on the door pillar, driver's door, or inside the glove box. The label will have specific information on tire size, inflation pressure, and the maximum vehicle load.

All tires' ratings are determined by a series of numbers located on the tire. The rating system identifies the size, wheel size, type of construction, speed rating, and load rating. A typical tire may have the following designation: **P 225/70 H R 15**. The letter **P** indicates that this tire is designed for passenger vehicles and some light trucks. Other designations are **T** for temporary use, **LT** for light truck, and **C** for large trucks or commercial. The number **225** indicates the width of the tire measured in millimeters. The higher the number, the larger the tire size. The number **70** is the aspect ratio of the tire's height to its width. The higher the aspect ratio number, the taller the tire. The letter **H** designates the speed rating. The rating specifies the maximum speed at which the tire can be driven safely. The rating range is from **B** (31mph) to **Z** (over 149 mph). The letter **R** indicates radial-ply construction. Bias-ply tires are marked **B.** The number **15** is the rim diameter in inches.

Tires are also graded for **temperature resistance, traction** and **tread wear.** Temperature resistance is graded on three levels: A, B, and C. "A" provides the greatest resistance to heat; "C" provides the least. Traction is also rated on three levels: A, B, and C. "A" will provide the best traction, especially on wet roads. A "C" rating will give the least amount of traction. Tread wear ratings use a numbering system ranging from 100 to approximately 500. The higher the number, the more mileage can be expected from the tire. A rating of 150 should yield about 50% more mileage than a tire rated at 100.

For safety reasons, a periodic tire inspection should be performed. Check for cuts, bulges, abrasions, stone bruises, and objects embedded in the tire. Most tires have tread wear indicators built into the tread. When the wear indicators appear at two adjacent treads at three or more locations around the tire, replace the tire. If the inner cord or fabric is exposed, the tire must be replaced.



Task E.3 Measure and adjust tire air pressure.

Overinflation causes wear on the center of the tire tread; underinflation causes wear on the edges of the tread. Underinflation may also cause wheel damage. Adjust tire pressure when the tires are cool.

Vans, trucks, and sport utility vehicles commonly require more pressure in the rear tires because of the loads they carry and to minimize sway. Putting more air in the tires on one side of the vehicle is never recommended.

All air pressure specifications on passenger cars and trucks are to be measured while the tire is cold. A cold tire is one that has been driven less than three miles. If the tires have been driven for more than three miles, they must be allowed to cool for two to three hours. Always refer to the vehicle manufacturer's specifications for the tire inflation pressure.

Task E.4 Diagnose wheel/tire vibration, shimmy, and noise concerns; determine needed repairs.

Tire and wheel vibration problems vary, depending upon the particular problem with the tire and/or wheel. Understanding the characteristics of a road test will help in the diagnosis.

Tire-induced vibrations, occur at all speeds. A tire with excessive radial runout (out of round) will cause a low-speed vibration that will seem to go away at highway speeds. A tire with lateral runout will tend to shimmy, especially at low speeds. A bent wheel may also cause a shimmy at all speeds.

Also, inspect the wheels for damage, cracks, and elongated mounting holes. A vibration at 55-65 mph is an indication of a wheel-balance problem.

Problems within the tire, shifting cords, and damaged tires can cause tires and wheels to become unbalanced. Sometimes a thumping noise can be heard from the tires when the tread becomes damaged or chopped. **Wheel tramp** is the term used when the tire hops up and down as it rotates. **Wheel shimmy** refers to the side-to-side shaking that occurs when a tire is not properly balanced. Replace damaged tires, and damaged or bent wheels.

Task E.5 Rotate tires/wheels and torque fasteners according to manufacturers' recommendations.

Most vehicle manufacturers recommend tire rotation at specified intervals to obtain maximum tire life. The exact tire rotation procedure depends on the model year, the type of tire, and whether the vehicle has a conventional or compact spare. For proper tire rotation procedures, refer to the vehicle manufacturer's service manual or owner's manual. There are several different recommended rotation patterns.

Most manufacturers use the modified "X" method which states "cross the non-drive and move the drive tires straight." When rotating tires, inspect the sidewalls of the tires for directional indicators; some tires are designed to rotate in a specific direction. Directional tires are typically rotated front to rear to keep the tires rotating in the correct direction. Some vehicles have directional wheels that are designed to work only on one side or one location on the vehicle. Directional tires offer better handling and response when they roll in the intended direction. They are also constructed with a particular tread design that channels away water more effectively, reducing the chances of hydroplaning.

Tighten all lug nuts to proper torque and sequence. Consult the service manual for specifications. Over tightening the lug nuts can cause damage to the wheel, distort the wheel studs, or warp the hub/bearing assembly.

Task E.6 Measure wheel, tire, axle flange, and hub runout (radial and lateral); determine needed repairs.

Excessive rear chassis waddle may be caused by a shifted steel belt in a tire, or a bent rear hub flange. Tire and wheel runout can be checked by using a runout gauge that follows the tire tread (radial runout), or the gauge can be placed on the sidewall of the tire (lateral runout).

If technicians carefully check runout of all of the parts involved and marks all of the high and low spots, they can correct excessive runout. New parts may not be necessary to correct the problem. Because front-wheel drive cars are lighter and smaller, they transmit noises, vibrations, harshness, and out-of-round conditions more than larger rear-wheel drive cars and trucks.

Task E.7 Diagnose tire pull (lead) problems; determine corrective actions.

Steering pull may be caused by front tires with different types, sizes, inflation pressure, or tread designs, or a front tire with a concentricity defect.

Concentricity is a term used in the tire industry when a tire bead is not centered on the tire body. The bead forms a cone, which causes the vehicle to pull in the direction of the small side of the cone. This condition is more commonly referred to by the technician as tire lead. An out-of-round condition in the rear will cause a vehicle to shake side-to-side. A front out-of-round tire will cause the steering wheel to shake, typically at lower speeds.

Task E.8 Dismount and mount tire on wheel.

Tires are mounted and dismounted from a wheel using a tire changer. A good tire changer allows the tire to be removed without damaging the tire's beads or the edges of the wheel.

When removing or mounting the tire, apply an approved tire lubricant to the bead area. Otherwise excessive strain may be put on the tire bead, resulting in damage to the tire. Clean the sealing area and inspect the wheel for cracks, dents, and burrs. Use a clip-on air chuck while inflating the tire and stand back. Wear safety glasses. Do not exceed 40 psi in an effort to seat the tire bead. If the bead will not seat, deflate the tire and examine the tire for the cause. After the tire is inflated, adjust to recommended pressure and check for leaks.

Task E.9 Balance wheel and tire assembly.

Dynamic wheel balance refers to the balance of a wheel in motion. Cupped tire treads, wheel shimmy, or excessive steering linkage wear may be caused by dynamic wheel imbalance.

A wheel and tire assembly that is statically unbalanced will bounce up and down. A wheel and tire assembly that is dynamically unbalanced will cause the wheel to shake from side-to-side. This is called a shimmy.

To bring a tire in static balance, weight is added to the rim opposite of the heavy side. The amount of weight necessary is determined by the weight of the heavy section of the tire. The added weight will compensate for the heavy part of the tire and bring the tire into correct static balance.

To be in dynamic balance, the tire must also be in static balance. The tire must be spun to check for dynamic imbalance. The wheel-balancing machine will detect any side-to-side imbalance and determine the location and weight to bring the tire in correct dynamic balance. After the weight is added, the tire should be spun again to check for accuracy.

There are many different types of wheel designs used today. Many vehicles are equipped with aluminum wheels. Always use the correct wheel weight designed for the wheel. Using the wrong weight may result in damage to the bead surface and wheel. The wrong design wheel weight may also fail because it may not fit correctly to the contour of the wheel bead area.

Task E.10 Test and diagnose tire pressure monitoring system; determine needed repairs.

The Tire Pressure Monitor System has a sensor in each tire attached to the inside of the rim to monitor the pressures. A light on the dash informs the driver if there is a problem with the tire pressures. When tires are rotated or loss of pressure occurs, the low air pressure light will have to be reset by putting the computer into diagnostic mode according to the manufacturer and the light reset according to manufacturer's procedures. Most cars have a reset mode that allows you to reset the light by turning the key on and letting a small amount of air out of each tire. There are also aftermarket reset tools that are designed to reset the lights the way a manufacturer would.