Automotive Technology

Module 5: Steering and Suspension Systems

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FOREWORD

Once again, we are indebted to the teachers and administrators who provide their time, efforts, and professionalism to develop curriculum for trade, technical, and industrial education programs. The *Introduction to Automotive Technology* module is an outstanding example of what can be accomplished when the right people with the right attitude work together. The curriculum writers and subject matter experts who worked on this guide are to be commended for a job well done.

The module's format has been developed for competency-based teaching and testing. All major components of the module have been keyed to the IML's Automotive Technology Competency Profile.

The format and curriculum management system found in this module may be new to many vocational educators. However, we are confident that, when used as designed, this module will allow for a more productive and rewarding educational experience for both the teacher and the student. Automotive technology, like many technical fields, is undergoing constant and considerable change. We will annually evaluate the need to update this guide on a module-by-module basis. Your suggestions regarding areas for improvement are both encouraged and appreciated.

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ACKNOWLEDGMENTS

The 1996 revision of *Introduction to Automotive Technology* is the first of nine modules to make up the Automotive Technology Curriculum Guide. Produced by the Instructional Materials Laboratory (IML), the guide represents IML's commitment to continual improvement of the Missouri Automotive Technology Curriculum. All modules in the guide are based on the Auto Mechanics Technology Competency Profile, which in turn is based on and cross-referenced to the ASE task list. For years ASE has set the professional standards for automotive technicians. Therefore, a strong ASE orientation makes the guide an effective tool for preparing students to enter the technological advanced field of automotive technology.

IML gratefully acknowledges the important contribution of the advisory committee, which, among other tasks, developed the competency profile for the guide. The advisory committee members are listed below:

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HOW TO USE THIS PUBLICATION

GUIDE COMPONENTS

Cross-Reference Table

The cross-reference table can quickly reveal how competencies relate to instructional objectives, job sheets, and test items.

Objectives

Each unit is based on performance objectives which state the measurable unit and specific behavioral or performance objectives that students are expected to achieve. Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the objectives' intent.

Information sheets

Presented in outline form for clarity, these pages provide content essential for meeting the cognitive (knowledge) objectives in the unit. Students should study the information sheets before class discussion or completion of assignment sheets. The corresponding student reference page number appears in the upper right hand corner of the Instructor Guide.

Tests

Tests evaluate students knowledge of the material.

Assignment Sheets

Assignment sheets allow students to respond to cognitive questions in writing.

Job Sheets

Job sheets are designed to guide students through various key tasks. Job sheets also provide a means for instructors to evaluate a student's performance of the task.

Suggested Activities

Students should perform the following activities:

1. Read objective sheet.
2. Study information sheets.
3. Take unit test.
4. Do job sheet(s).

CONTENTS OF
MODULE 5: STEERING AND SUSPENSION SYSTEMS

REFERENCES

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MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT I: STEERING SYSTEM DESIGN

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the components and operating principles of different types of steering systems. The student will demonstrate mastery of the material by achieving a score of _____ on the unit test.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with steering systems (Competencies R1-R8, Unit I Test).

II. Identify conventional steering system components for manual and power systems (Competencies R1-R3, Unit I Test).

III. Identify linkage components (Competency R7, Unit I Test).

IV. Identify the basic steering linkage designs used on manual and power steering systems (Competency R7, Unit I Test).

V. Identify power and manual rack and pinion steering components (Competencies R4 and R5, Unit I test).

Lesson 2.

I. Identify manual steering gear components (Competencies R2 and R3, Unit I Test.)

II. Identify the principles of hydraulics (Competencies R2-R5 and R8, Unit I Test).

III. Identify the operating principles of the power steering pump (Competency R8, Unit I Test).

IV. Identify the operating principles of the integral rotary valve power steering system (Competencies R2 and R3, Unit I Test).

V. Identify the operating principles of the integral gear spool valve and pivot lever power steering system (Competencies R2 and R3 Unit I Test).

VI. Identify the operating principles of the linkage type power steering system (Competencies R2 and R3, Unit I Test).

Lesson 3.

I. Identify the operating principles of the manual rack and pinion steering system (Competencies R4 and R5, Unit I Test).

II. Identify the operating principles of the power rack and pinion steering system (Competencies R4 and R5, Unit I Test).

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT I: STEERING SYSTEM DESIGN

CONTENTS OF THE UNIT

A. Objective sheet

B. Lesson plans

1. Lesson 1: INTRODUCTION TO THE STEERING SYSTEM

    a. Information outline

    b. Assignment sheet

    AS1-L1-UI: Types of Steering Systems

2. Lesson 2: CONVENTIONAL STEERING SYSTEM COMPONENTS AND THEIR FUNCTIONS

    a. Information outline

    b. Assignment sheet

    AS1-L2-UI: Functions of Conventional Steering System Components

3. Lesson 3: MANUAL AND POWER RACK AND PINION STEERING COMPONENTS AND OPERATION

    a. Information outline

    b. Assignment sheet

    AS1-L3-UI: Rack and Pinion Components

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT I: STEERING SYSTEM DESIGN

LESSON 1: INTRODUCTION TO THE STEERING SYSTEM

I. Terms and definitions

A. **Ball socket** — In a steering system, a moveable joint that tilts and rotates. The ball socket consists of a stud with a ball on one end. The ball fits securely in a socket assembly.

B. **Center link** (also known as a drag link or relay rod) — A rod that transfers motion from the pitman arm to the left and right tie rods. The center link is held in position by the idler arm.

C. **Control valve** — A valve assembly that controls the flow of pressurized power steering fluid to the power cylinder.

D. **Idler arm** — An arm that is attached to the vehicle frame on one end and to the steering linkage on the other. The idler arm supports the center link and allows the steering motion to be directed to the tire rods.

E. **Pitman arm** — The connecting link between the steering gear and the center link.

F. **Power cylinder** — A hydraulic cylinder attached to the steering linkage. When pressurized, the power cylinder assists the driver in turning the wheels.

G. **Power steering** — A steering system that uses hydraulic pressure to make steering easier.

H. **Steering pump** — A hydraulic pump that pressurizes and circulates power steering fluid. The pump is usually driven by a belt running from the crankshaft pulley to another pulley attached to the pump shaft.

I. **Rack and pinion steering** — A steering gear with a pinion gear attached to the steering shaft. The pinion gear runs in a rack (a long bar with gear teeth), which is attached to the wheels by tie rod assemblies.

J. **Steering column** — An assembly that contains the steering shaft. (The steering shaft connects the steering wheel and steering gear.) The steering column is mounted under (and usually supported by) the instrument panel. The steering column may contain portions of the gear shift mechanism and/or electrical wiring for various components.

K. **Steering dampener** — An assembly that resembles a shock absorber in appearance and operation.

L. **Steering gears** (also known as steering gear box) — The gears mounted in a housing at the lower end of the steering column. Steering gears reduce the effort needed to turn the steering wheel.

M. **Steering knuckle** — The inner portion of the spindle. The steering knuckle is supported by and pivots on either the upper and lower ball joints or a king pin. The steering knuckle may either be an integral part of the spindle or simply bolted to it.

N. **Tie rod assembly** — A term used to describe the tie rod ends and adjuster sleeve.

O. **Tie rod adjuster sleeve** — A split tube with internal threads. The tie rod adjuster sleeve connects two tie rods and allows for toe settings. The tie rod adjuster sleeve is held in place with clamps.

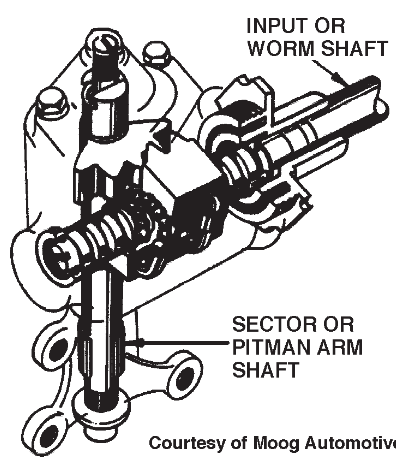
P. **Tie rod end** — A ball socket assembly that is connected to a steering knuckle or center link.

II. Conventional steering system components for manual and power systems

A. Manual steering gear

1. Most manual steering gears are of the recirculating ball nut design. This design uses steel balls between a worm gear and a rack gear, which is machined into a ball nut. The steel balls act as a rolling thread to provide minimum friction when turning.

2. The average gear ratio of a manual steering gear is about 24 to 1. At this ratio, the steering wheel and steering shaft, which are coupled to the worm gear shaft, must turn 24 times in order to turn the output or sector shaft once. Such a large ratio greatly reduces the effort required to turn the steering wheel.

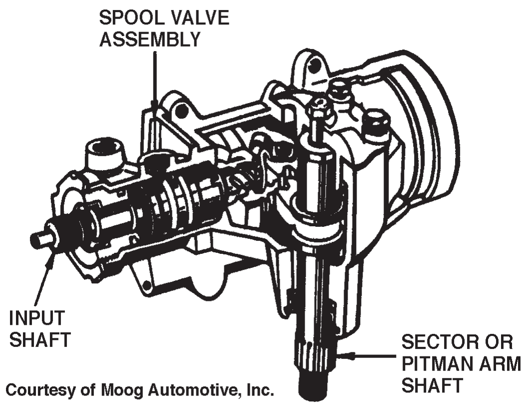


Courtesy of Moog Automotive, Inc.

B. Integral power steering

1. The typical integral power steering gear has many components similar to those in a manual steering gear. Both use a worm shaft and a sector or pitman shaft. Many integral power steering gears use a recirculating ball nut similar to those in the manual gear.

2. A unique component of the power steering gear, however, is a hydraulic power piston and a control valve. The power piston uses hydraulic oil pressure to provide most of the force needed to turn the wheels. The average power steering gear ratio is about 15 to 1. This ratio provides the driver with quicker turning response. If the hydraulic steering system should fail or if the engine should stall, the driver will still be able to steer the vehicle, although doing so will require extra effort.

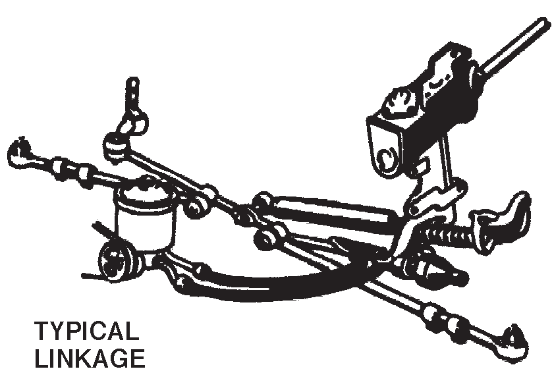


Courtesy of Moog Automotive, Inc.

C. Linkage-type power steering

1. A linkage-type power steering system uses an external, double-acting hydraulic cylinder and control valve. One end of the cylinder is attached to the steering linkage under the vehicle; the other end is attached to the vehicle's frame.

2. When the steering wheel is turned, the hydraulic cylinder is pressurized and provides some of the force needed to turn the wheels. The linkage-type power steering utilizes a manual style steering gear box. If the pump or some other part of the hydraulic steering system should fail or if the engine should stall, the driver will still be able to steer the vehicle, although doing so will require extra effort.



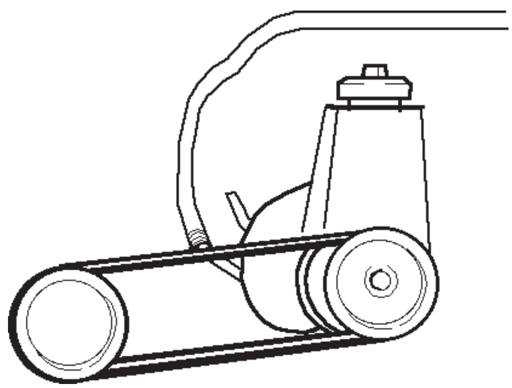
Courtesy of Moog Automotive, Inc.

D. Power steering pump

1. The power steering pump pressurizes and circulates power steering fluid. The three common types of power steering pumps are the vane, the roller, and the slipper. All three types are similar in operation. These pumps will be covered in more detail later in this unit.

2. The power steering pump is normally driven by a V-belt or a V-ribbed belt. Power steering pumps are capable of producing pressure in the range of 1000 to 1500 psi. The power steering pump should never run when the fluid level is significantly low. The power steering fluid should, therefore, be checked regularly.

   (**NOTE:** Most late-model vehicles with power steering require the use of approved power steering fluid.)



E. Power steering hoses transfer hydraulic pressure from the power steering pump to the gear assembly and back to the pump. Power steering hoses are usually constructed of reinforced synthetic rubber or a similar material. The hoses are coupled to metal tubing at connecting points.

   (CAUTION: Always wear eye protection to protect eyes from pressurized oil. Always use a hose capable of handling system pressure.)

III. Linkage components

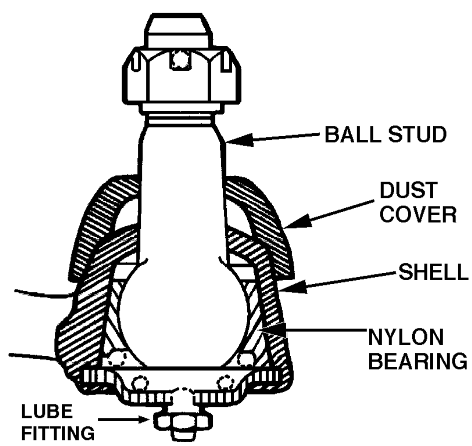
A. Tie rod ends

1. A conventional tie rod end consists of a tapered ball stud that is inserted in a steel or nylon bearing socket. A spring or plastic spacer holds the ball in position in the socket.

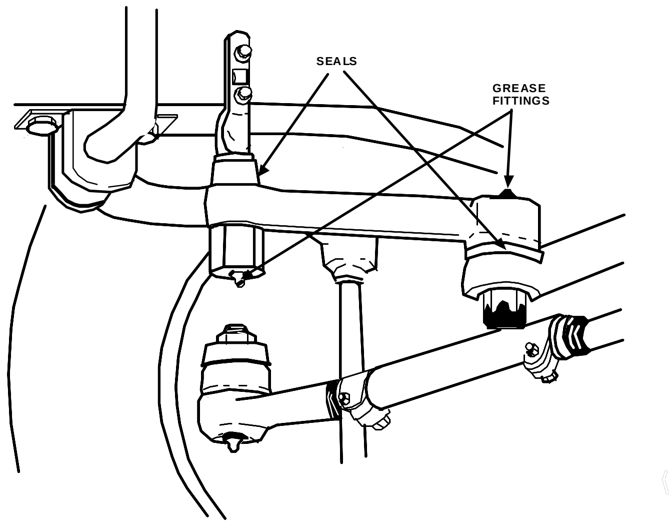
2. A forged outer shell encases the socket assembly. Some outer shells have a threaded hole that accepts grease fittings for lubrication. In other cases, the sockets are lubed and sealed during assembly and require no additional lubrication. A threaded rod is an integral part of the outer shell. The rod may have right- or left-handed threads, depending on its location in the steering linkage. A rubber dust cover fits over the ball stud and shields the ball socket from dirt and moisture. Ball sockets similar to those used in tie rod ends are sometimes used at other steering linkage connecting points.

B. A rubber bonded socket tie rod end consists of a tapered ball stud with a molded rubber element on one end and a tie rod housing on the other. The stud is pressed into the housing; a lip is rolled over to hold the housing in place. The rubber element's tight fit prevents it from turning in the socket. The joint has no moving surfaces and, therefore, requires no lubrication. The joint moves as a result of the rubber element's twisting action.

TIE ROD END



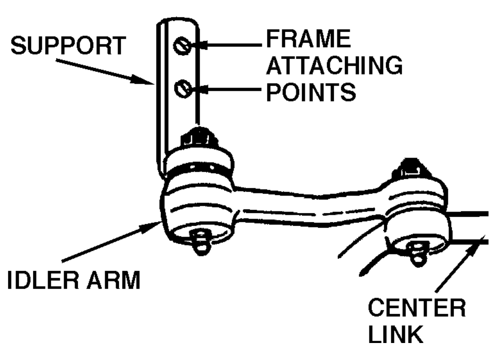
C. A tie rod sleeve is an internally threaded tube, that screws over and connects two tie rod ends. The tie rod sleeve is threaded with left-handed threads on one end and right-handed threads on the other. Turning the sleeve will move the tie rod ends closer together or farther apart, thus providing a means for toe adjustment. The ends of the sleeve are split and surrounded by a clamp. When tightened, the clamp squeezes the sleeve and holds it in position on the tie rod end.



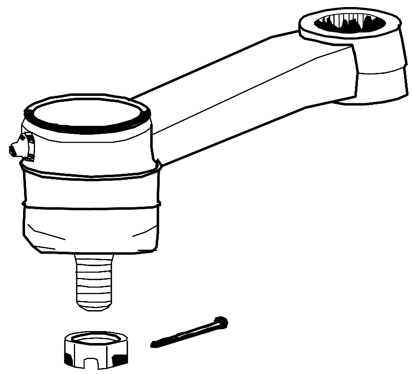
D. Idler arm

1. One type of idler arm uses a metal and rubber bushing assembly. A steel outer shell is press fit in the idler arm. A rubber insert is bonded to the inside of the outer shell and to a steel sleeve inside the rubber insert. This assembly is bolted securely to the idler arm support bracket through the inner sleeve. When the steering linkage moves, the rubber insert twists in the metal shell. The idler arm may attach to the steering linkage through another bushing arrangement or a ball socket.

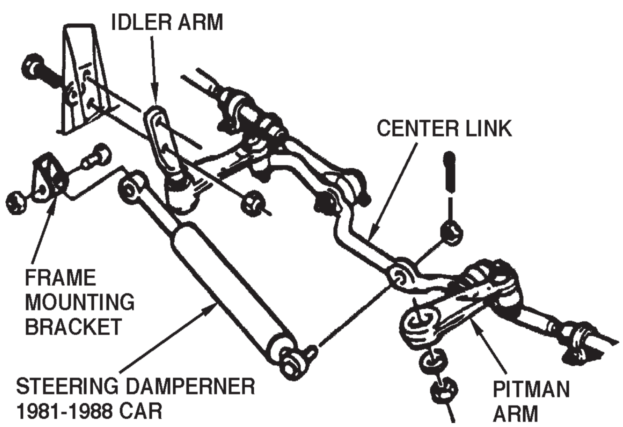
2. Another type of idler arm has a threaded bushing arrangement. The lower end of the support for this idler arm has external threads, which match internal threads in the arm. Linkage movement causes the arm to turn on the threads. A grease fitting is provided for lubrication.



E. The pitman arm is splined at one end to the sector shaft and held in place with a hex nut or pinch bolt. The other end is attached to the center link by a ball and a socket. The ball and socket may be on the pitman arm or the center link.

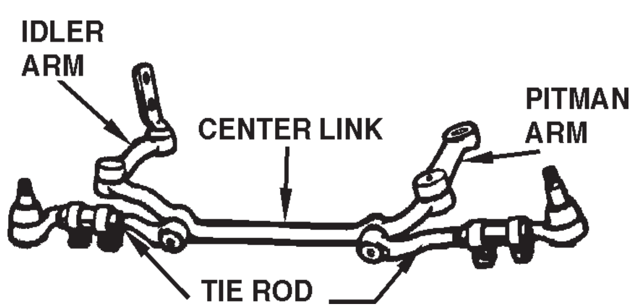


F. Some vehicles use a steering dampener to absorb steering wheel oscillations (shimmy). The dampener can be installed during manufacture or added later. The dampener is mounted from the vehicle frame to the steering linkage. Mounting hardware includes rubber grommets, which reduce noise and vibration. The dampener uses a rod with a piston attached to one end. The piston travels back and forth in an oil-filled cylinder as the vehicle's wheels are turned. Special orifices allow oil to flow in and out of the piston chambers at a controlled rate, thus preventing the steering linkage from moving rapidly back and forth.

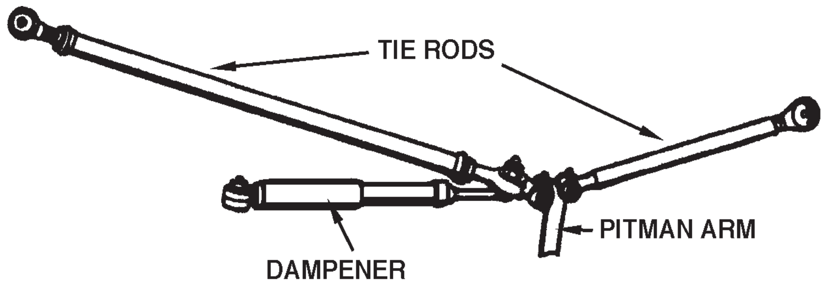


IV. Linkage designs

A. The parallelogram linkage design uses two tie rod assemblies of equal length, a pitman arm, an idler arm, and a center link. The parallelogram is the most commonly used linkage design.

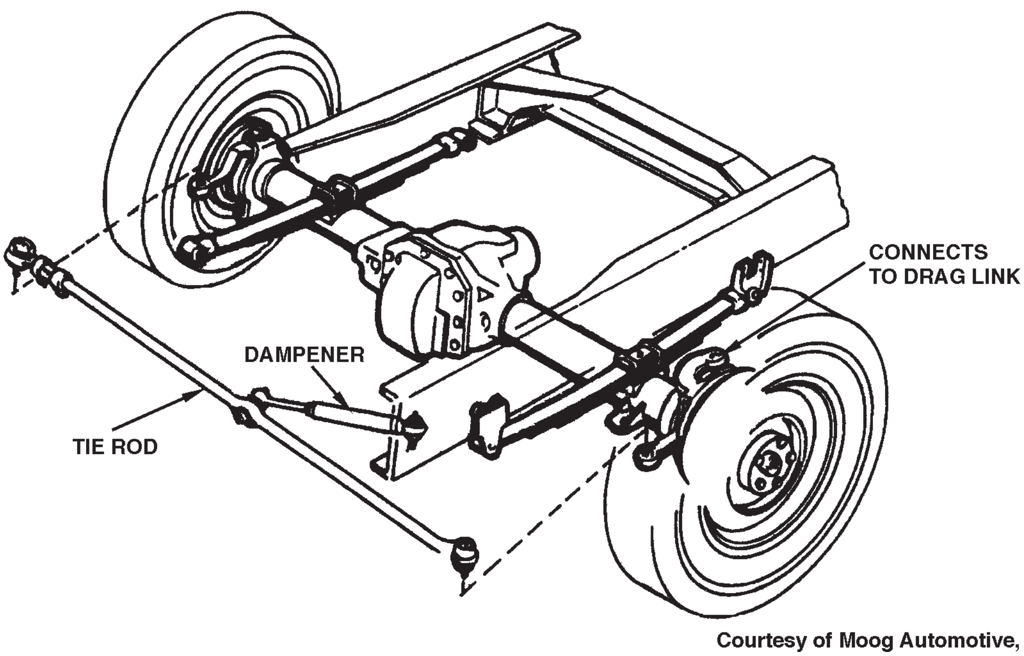


B. The center point linkage design consists of one long and one short tie rod assembly with a center steering (pitman) arm. A steering dampener is used in center point linkage designs.



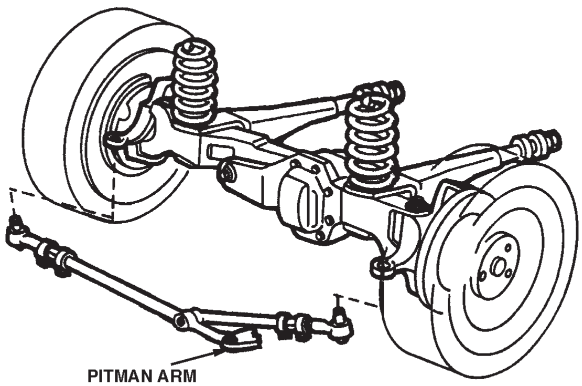
Courtesy of Moog Automotive, Inc.

C. Truck straight axle and four-wheel-drive axle steering linkage designs commonly use on long tie rod assembly, which connects to both steering knuckles. A second arm can be found on the rear of the left steering knuckle. A drag link (short tie rod assembly) connects this second arm to the pitman arm. A truck straight axle and four-wheel-drive axle steering linkage sometimes includes a dampener.



Courtesy of Moog Automotive, Inc.

D. The twin I-beam axle steering linkage design uses a long tie rod assembly that runs from the pitman arm to the right steering knuckle. A shorter tie rod assembly extends from a point on the longer tie rod to the left knuckle.



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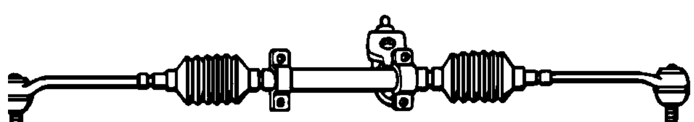
V. Rack and pinion steering components (manual and power steering)

A. Manual rack and pinion steering consists of a pinion gear, which meshes with a long rack gear. When the steering wheel is turned, the pinion drives the rack to the left or right. Inner and outer tie rod assemblies connect the rack to the wheels. Rack and pinion steering offers several advantages, that are listed below.

1. The rack and pinion steering system is relatively smaller than conventional sys tems and thus weighs less. The rack and pinion's small size is also well-suited to today's smaller cars.

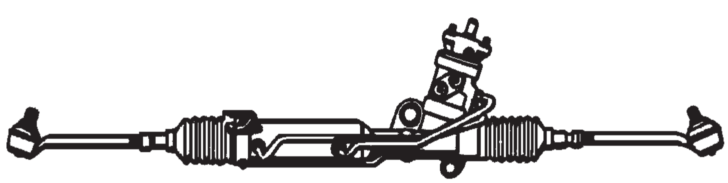
2. In rack and pinion systems, the steering gear is located under the car (instead of in the engine compartment), thus providing more room in the engine compartment.



Courtesy of Moog Automotive, Inc.

B. A power rack and pinion steering system functions much like a manual system. The power system, however, integrates a double-acting power piston into the rack. A valve on the pinion gear shaft controls fluid flow. The power rack and pinion steering system is also compact and lightweight. However, the system's housing must be larger to accommodate the extra power-assistance components.

(**NOTE:** The pump used to operate a power rack and pinion steering unit is similar to one used by conventional power steering systems.)



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AS1-L1-UI

MODULE: STEERING AND SUSPENSION SYSTEMS

TYPES OF STEERING SYSTEMS

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. What type of gear design is commonly used in manual steering systems?

2. Name two basic power steering system designs.

3. Power steering pumps can produce what range of pressure?

4. What is the average power steering gear ratio?

5. Name the three most common types of power steering pumps.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT I: STEERING SYSTEM DESIGN

LESSON 2: CONVENTIONAL STEERING SYSTEM COMPONENTS AND THEIR FUNCTIONS

I. Manual steering gear components

A. The worm shaft and recirculating ball nut assembly is the input shaft of the steering gear. Adjustable ball thrust bearings support the worm shaft and recirculating ball nut assembly in the gear housing.

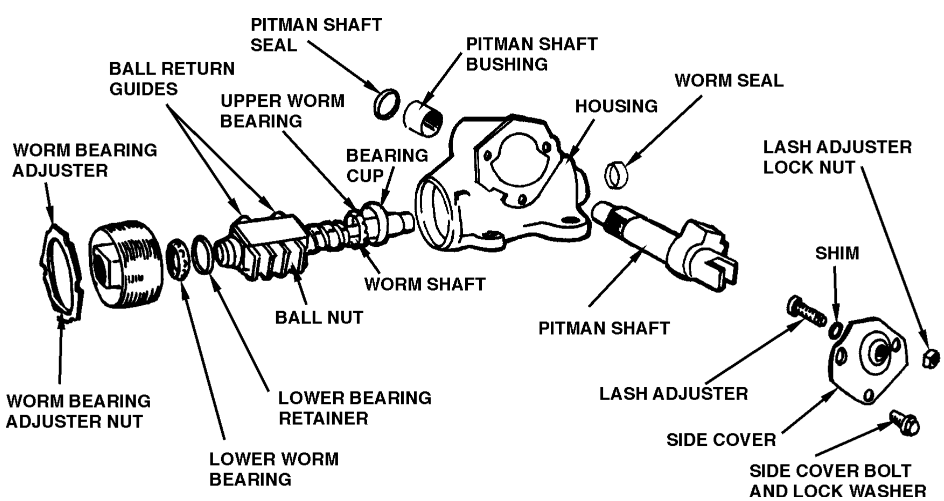
1. The inner surface of each thrust bearing is machined into the worm shaft as are special spiral grooves. These grooves are used in place of the teeth found on a common worm gear. The grooves provide a rolling surface for the steel balls in the ball nut.

2. Splines on the worm shaft's upper or exposed end connect the worm shaft to the steering shaft, usually through a flexible coupling.

3. The recirculating ball nut assembly works much like a common nut in that as the worm shaft is turned, the ball nut is screwed up or down the shaft. The recirculating ball nut differs from a common nut in the ways described below.

a. Instead of conventional threads, the ball nut has internal grooves, which match the external worm shaft grooves. Steel balls roll in these grooves, thus resulting in a rolling thread.

b. Manual steering gears generally have two sets of balls (containing about 20 to 30 balls per set). Each set rolls in its individual circuit, which consists of the ball nut and worm shaft grooves and special tubes called ball return guides. These guides are attached to the outside of the nut.



c. If the steering wheel is turned to the left, the worm shaft also turns. As a result, the balls roll through their circuit between the worm shaft and ball nut, which, in turn, moves the ball nut up or down the shaft.

d. As the balls roll to the end of the ball nut, they move through a drilled passage and enter a ball return guide (located on the outside of the nut). Upon leaving the return guide, the balls re-enter the nut through another drilled passage and can then repeat the circuit.

e. If the steering wheel was turned to the right, the balls would circulate in the opposite direction, causing the ball nut to move in the opposite direction on the worm shaft.

(**NOTE:** The recirculating ball nut assembly creates less friction, resulting in easier steering and less steering gear wear.)

B. The sector shaft serves as the output shaft of the steering gear. The sector shaft's rotary motion is transferred directly to the steering linkage via the pitman arm. (The sector shaft is also referred to as a pitman shaft.)

1. The sector shaft is made of heavy steel and is supported in the gear housing by needle bearings or bronze bushings pressed into the gear housing. Splines are machined into the output end of the sector shaft; the output end is also threaded below the splines. The pitman arm fits tightly onto the splines and is held firmly in place by a nut screwed onto the threads. A sector gear (a special coarse-toothed gear) is an integral part of the sector shaft. The sector gear meshes with the rack teeth on the ball nut.

   a. The sector shaft is not required to make a complete revolution; the shaft must move only far enough to cause adequate lateral pitman arm movement to steer the vehicle. Therefore, only a few sector gear teeth surround the circumference of the sector shaft.

   b. The sector gear teeth are slightly tapered; the gear lash (clearance) between the sector gear and the sector shaft can be adjusted by raising or lowering the sector shaft in its housing. The upper end of the sector shaft has a slot in which an adjusting screw is attached. This screw is threaded into a portion of the gear housing. Turning the screw changes the gear mesh.

2. When the steering wheel is turned, the worm shaft also turns, causing the ball nut to move. Upon moving, the ball nut's rack teeth exert force against the sector shaft teeth, causing the sector shaft to rotate.

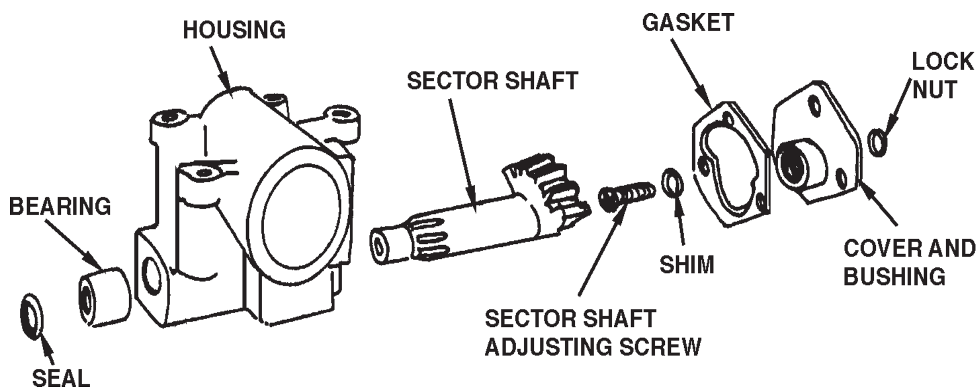
C. The gear housing is usually made from either die-cast aluminum or cast iron. The housing holds and supports both the worm shaft and the sector shaft. Lubricant is also contained within the housing.

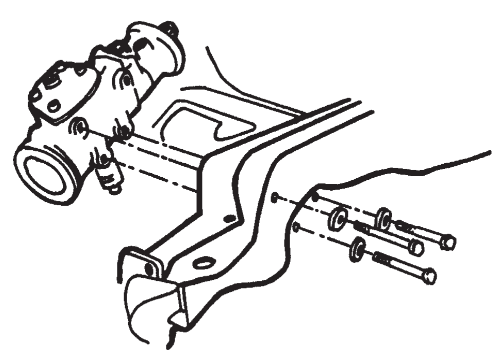
1. Most gear housings have a machined opening for bearing cups and bushings, which are used in the worm and sector shafts. Cap screws hold a sector shaft cover to the gear housing. This cover conceals an opening through which the sector shaft can be removed. The sector shaft cover contains a bearing or bushing that also supports the sector shaft. A threaded hole in the cover accepts the sector shaft adjusting screw.

2. A threaded hole in the gear housing (opposite the worm shaft bearing cup) allows for removal of the worm shaft. The worm shaft bearing adjuster screws into this hole. The adjuster contains the second worm shaft bearing cup, which is held in place by a press fit. The worm shaft bearing adjuster is usually found on the upper end (or steering shaft end) of the gear housing; however, the adjuster is sometimes located on the opposite end.

3. A seal in the gear housing retains oil at the sector shaft. Another oil seal is located either in the gear housing or worm shaft adjuster at the worm shaft opening.

4. The gear housing is bolted to the vehicle's frame. The steering gear assembly is usually designed so that the sector shaft is positioned vertically. In some assembly designs, the sector shaft is positioned horizontally.





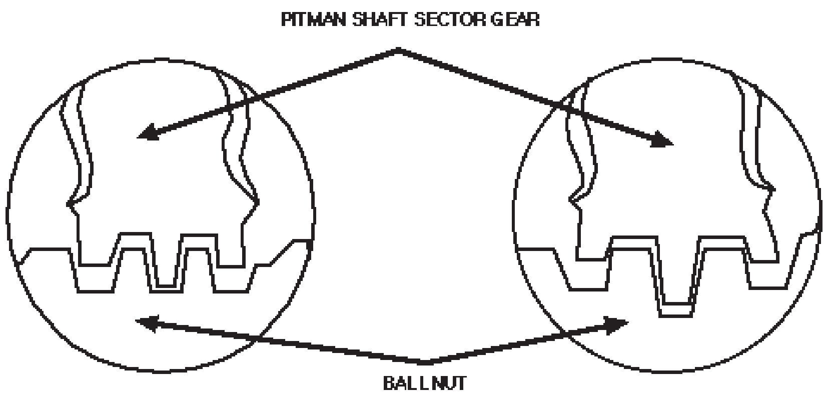
5. Constant and variable ratio steering

   a. A variable ratio gearbox changes the internal gear ratio as the front wheels are turned from the center position. Most modern recirculating ball gear boxes are variable ratio.

b. Variable ratio steering is faster when cornering, requiring fewer turns of the steering wheel from full right to full left. It also provides better control and response when maneuvering.

c. Variable ratio steering is accomplished by changing the length of the gear teeth on the sector shaft gear. This changes the effective lever arm action between the gears. Many manual steering gearboxes and most power steering gearboxes are variable ratio.

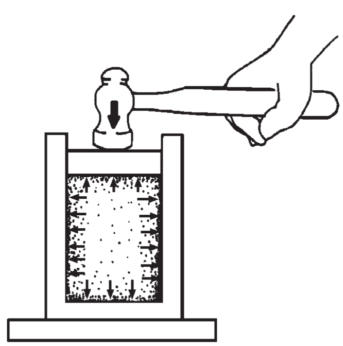
d. A constant ratio gearbox has the same gear reduction from full left to full right. The sector gear teeth are the same length.



II. Principles of hydraulics

A. Pascal's Law

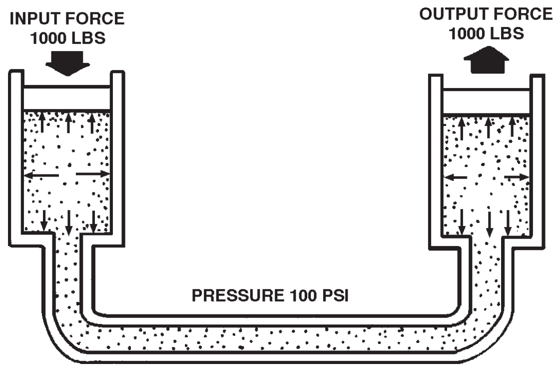
1. According to Pascal's Law, liquids (unlike gases) cannot be compressed. Pressure applied to a confined liquid is transmitted equally and undiminished in all directions. Liquid under pressure, therefore, can be used much like a mechanical lever.



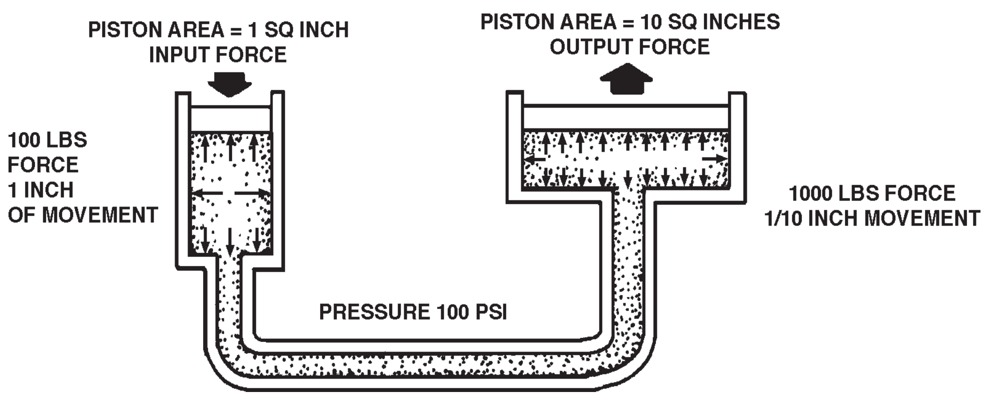
2. Pascal's Law defines pressure as force divided over the area where it is distributed. Pressure is measured in pounds per square inch (psi) or kilopascals (kp).

B. Pascal's Law in relation to fluid motion and multiplying force

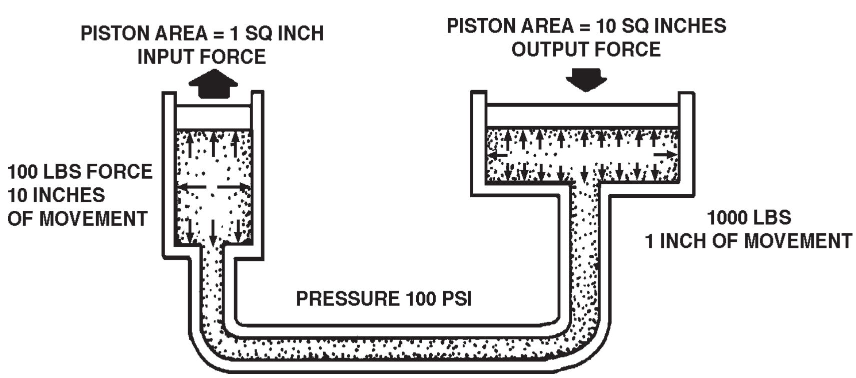
1. In systems where the input and output pistons are the same size, the force and motion generated by the input piston will be equal to the force and motion generated by the output piston.



2. In systems where the input piston is smaller than the output piston, force will be multiplied and the motion of the output piston will decrease.



3. In systems where the input piston is larger than the output piston, force will be decreased and the motion of the output piston will increase.



4. The distance that the output piston travels is inversely proportional to its surface area (as the surface area compares to the input piston).

C. Pascal's Law applies to the power steering system. The power steering pump transfers the hydraulic pressure through a hose or line in order to move the power piston. In other words, the power steering pump converts mechanical force from the vehicle's engine into hydraulic force and transfers it to the power piston; by its movement, the power piston converts the hydraulic force back to mechanical force. Because force moves through liquid undiminished, the pump can move the piston with great efficiency.

III. Power steering pump

A. As was stated above, the power steering pump converts mechanical force from the vehicle's engine into hydraulic pressure, which reduces the effort required to turn the steering wheel. The vane, the roller, and the slipper are three types of power steering pumps commonly used on today's vehicles. All three pumps function in a similar manner.

B. Power steering pump components

1. The pump housing contains the entire pump assembly with the exception of the fluid reservoir. The housing supports the input shaft on a bushing, which is pressed into the housing's shaft bore. An oil seal at the shaft bore prevents the escape of fluid. Threaded mounting holes in the housing allow the pump to be attached to the vehicle. A separate rear cover, which is held in place by cap screws or a retaining ring, encloses the back opening of the housing.

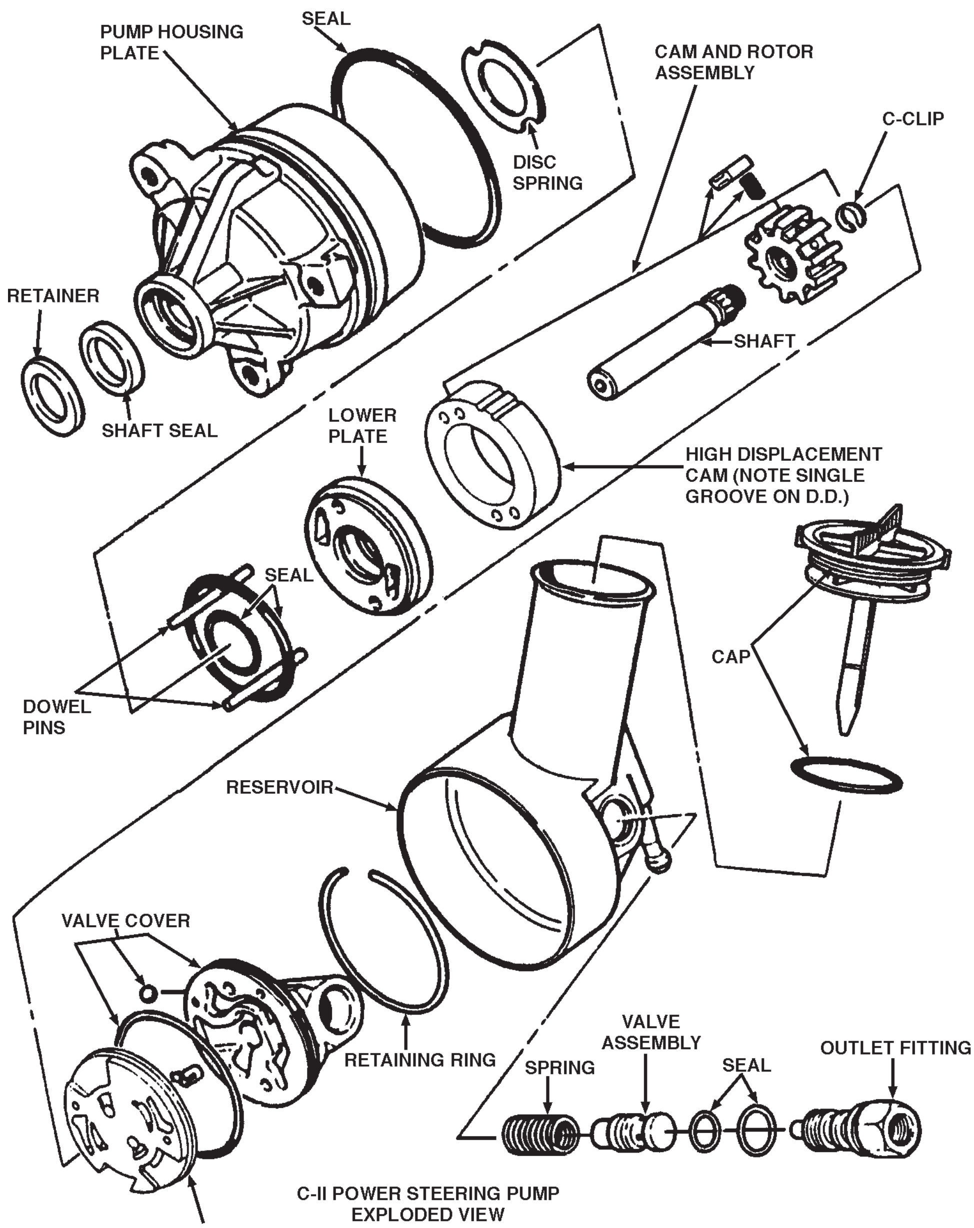
2. The steel pump shaft is supported in the pump housing by a bronze bushing. A pulley is attached to the portion of the shaft extending outside the pump. The pulley is either press fit between the shaft and pulley or threaded onto the end of the shaft with a shaft key and nut.

3. The pump's rotor is attached to the portion of the shaft located inside the housing. The rotor is either press fit to the shaft or connected to it by splines and a retaining ring. Either vanes, spring-loaded slippers, or steel rollers are contained in each of the slots or grooves around the rotor's circumference.

4. The pump's cam ring is a steel plate with a cam-shaped (or eccentrically shaped) center hole. The rotor turns inside the cam ring; the action of the vanes running against the cam's surface draws hydraulic fluid from the pump reservoir. The pump then discharges the fluid under pressure.

   (**NOTE:** A pump using slippers or rollers in the rotor produces similar results.)

5. The pump's pressure plate, constructed of flat, ground-steel, is located against the sides of the cam ring. The pressure plate retains the fluid in the cam ring; the plate also has special passages that direct fluid in and out of the cam ring/rotor assembly. Steel dowel pins hold the cam ring and pressure plates in position. A spring behind the rear pressure plate holds the cam ring and



C-II POWER STEERING PUMP
EXPLODED VIEW

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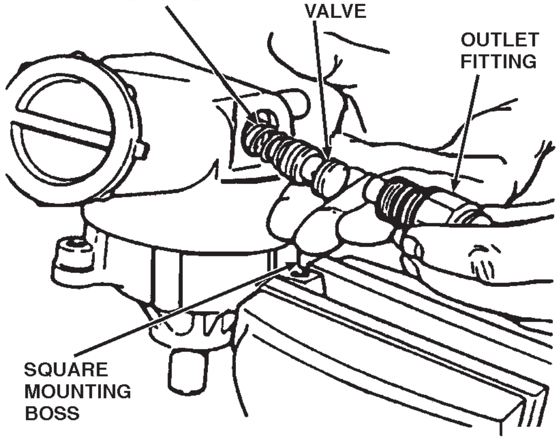
6. The pump's flow control valve (a spool valve) reduces the amount of fluid that the pump delivers to the steering gear assembly during excessive pump output (such as might occur during high-speed driving). The valve, therefore, reduces fluid temperatures and conserves engine power. Spring pressure in the valve reduces fluid flow. With the engine running and no pressure demand from the gear, the pump flow overcomes the spring pressure and opens the valve.

a. An orifice (a small hole) directs a metered amount of fluid from the pump to the spring side of the flow valve. As pump output increases, so does pressure on the spring side of the valve; thus, a regulated flow from the pump is maintained. The pressure is always lower on the spring side of the pump due to a pressure drop, which occurs as fluid travels through the orifice.

b. The flow control valve includes a built-in pressure relief valve, which limits pump output pressure to a predetermined level. When the predetermined level is reached (during parking, for example), a steel ball lifts off its seat against spring pressure, sending fluid back into the reservoir until output pressure is acceptable.



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7. Constructed of either stamped steel or fiberglass- reinforced nylon, the pump reservoir is usually fitted over the outer circumference of the pump housing. The reservoir is usually held in place by studs or bolts. A rubber o-ring seals the pump to the reservoir. Most reservoirs have a dipstick attached to the reservoir fluid filler cap.

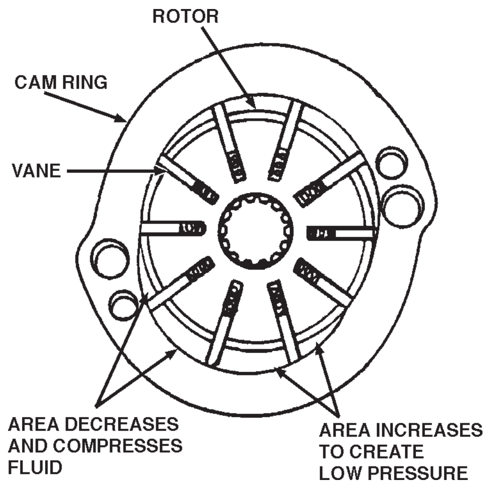
   (**NOTE:** On some pumps, the reservoir is mounted at a remote location above the pump. A hose connects the reservoir to the pump inlet.)

C. Operation of the vane power steering pump

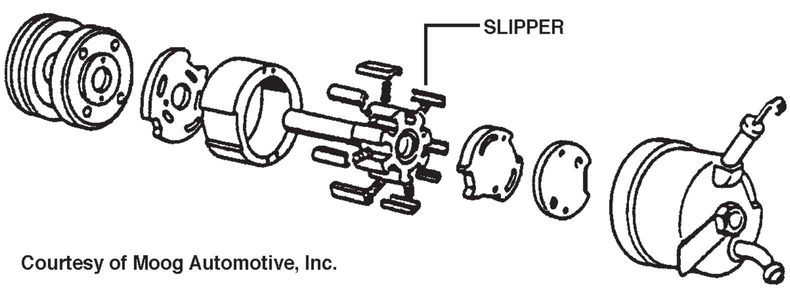
1. As the rotor begins to turn, centrifugal force moves the vanes out against the cam ring. The vanes will form spaces between the rotor and the cam ring. Fluid is drawn from the pump's intake port into these spaces.

2. The spaces between the rotor and cam ring become smaller as the rotor continues to turn. The fluid in the spaces is, therefore, pressurized and forced out through discharge ports in the pressure plate.

3. As pressure starts to build in the pump, pressurized fluid is directed under each vane in the rotor slots, forcing the vanes tight against the inside oval surface of the cam ring. The pressurized fluid is then directed through the flow control valve and discharged from the pump.

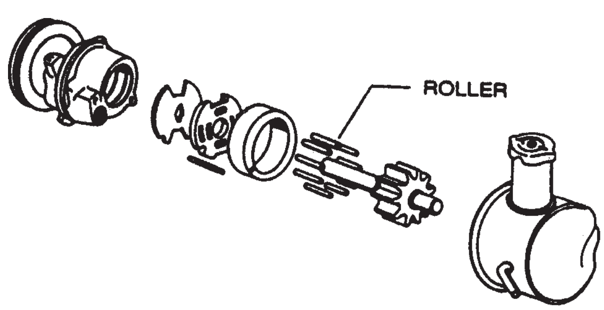


D. Slipper power steering pumps operate in basically the same manner as vane pumps. In the slipper pump, however, spring-loaded slippers (not rectangular vanes) ride against the cam ring.



Courtesy of Moog Automotive, Inc.

E. Roller power steering pumps operate in basically the same manner as vane pumps. In the roller pump, however, steel rollers fit into each rotor segment and move out against the cam ring as the rotor turns.



Courtesy of Moog Automotive, Inc.

IV. Rotary valve integral power steering system

A. Operation of the rotary valve integral power steering system

1. Many power steering gears use a recirculating ball nut similar to those found in manual steering gears. The hydraulic power piston is an integral part of the recirculating ball nut.

2. The power piston travels in a machined bore within the gear housing. The piston and gear housing allows pressurized fluid to reach either side of the piston. A teflon sealing ring is fitted into a ring groove, which is machined into the piston's outer circumference. The ring acts as a seal between the piston and housing. A rubber o-ring is installed under the teflon ring to reinforce the seal. When the rotary control valve admits pressurized fluid to the piston nut, hydraulic force is applied to one of the piston surfaces. This force assists in moving the piston nut up or down the worm shaft.

3. Unlike nonpower steering units, the worm shaft does not extend through the end of the steering gear case. A stub shaft connects the worm gear to the steering wheel and steering shaft via a flexible coupling at the base of the steering column.

4. The stub shaft extends into the steering gear housing and is connected to the worm shaft by a torsion bar. (A torsion bar is a spring steel rod, one end of which is anchored while the other end is free to twist.)

5. Some manufacturers make the ball groove more shallow toward the worm shaft's center; doing so allows for a slight preload to the balls between the worm and piston nut while the steering wheel is in the straight-ahead position. This design (referred to as high center) gives the vehicle more steering stability. Other manufacturers achieve steering stability by providing a tighter fit between the rack and sector gear.

6. The worm shaft receives end thrust as the rack piston moves up or down. Thrust bearings on both ends of the worm shaft control the end thrust.

B. Gear housing of the integral rotary valve power steering system

1. The sector shaft, piston-ball nut, and worm shaft are all contained in the gear housing. In some cases, the housing also contains the rotary control valve assembly; in others, a separate control valve housing attaches directly to the upper end of the gear housing. The gear housing supports the stub shaft with a bearing, which is located at either the upper end of the gear housing or at the control valve housing.

2. A fluid seal is located at both the stub shaft opening and the sector shaft. Most gear housings have a double seal arrangement at the sector shaft. The gear housing must be filled with fluid at all times. In addition to providing lubrication, the fluid absorbs road shocks and vibration, which might affect the steering gear. A check valve, located in the inlet pressure port of the gear housing, reduces steering wheel kickback.

   a. Kickback occurs when a bump in the road knocks the vehicle's front tires in an undesirable direction. Kickback can be transferred from the tires, through the steering linkage, into the steering gear and finally up to the steering wheel.

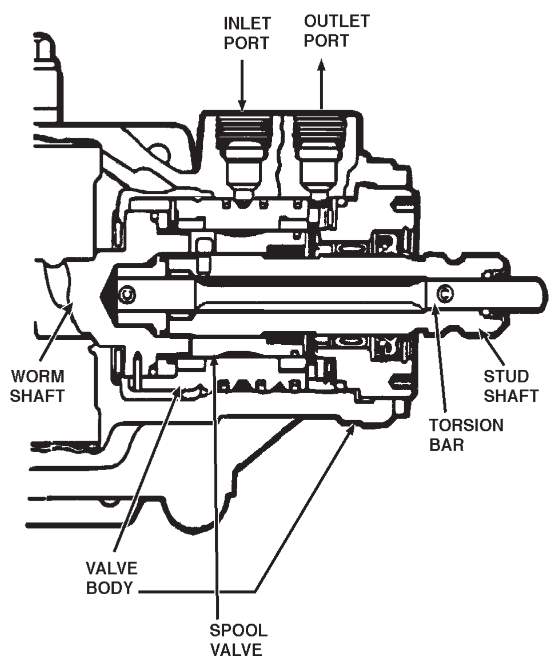
b. Upon reaching the power piston, kickback will attempt to force surrounding fluid back through the rotary control valve and out of the pressure port. The check valve located in the gear housing pressure port prevents fluid from being forced back. If the fluid were forced back, the steering wheel would move abruptly in the driver's hands.

C. In the integral rotary valve power steering system, the sector shaft is integral with the sector gear. The design and function of the sector shaft differs little from manual steering gear sector shafts.

D. The rotary valve

1. In the integral rotary valve power steering system, the rotary valve directs the pressurized fluid to the proper side of the power piston during turning. The valve also stops fluid flow to the rack piston when no power assistance is needed. The valve is located in the upper (or input) end of the gear housing. Some gear designs contain the control valve in the main gear housing while others have a separate control valve housing, which is bolted to the main gear housing. With the exception of a pressure line reaching from the pump to the gear inlet and back, neither design uses any exterior fluid lines.

2. The twisting of a torsion bar opens and closes the valve.

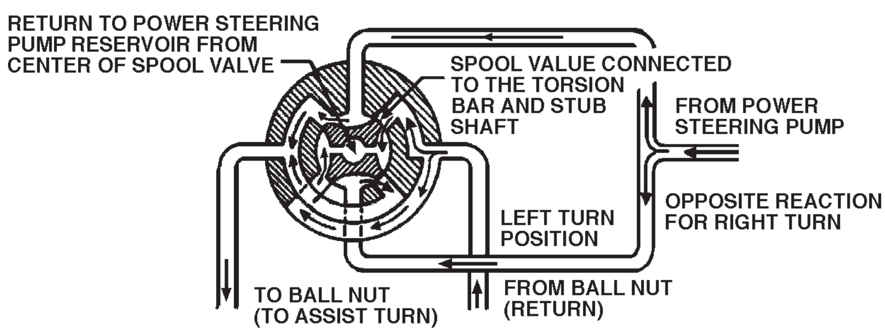


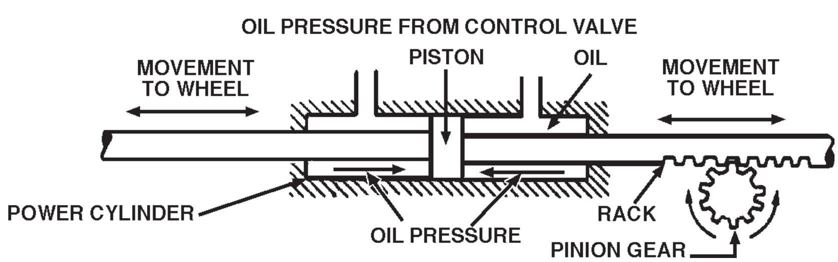
3. The rotary valve assembly pictured above consists of a stub shaft, valve body, valve spool, valve body cap, and worm shaft. A torsion bar connects all these components. Outlined below is a description of the valve's operation.

a. The stub shaft (which attaches to the steering wheel through the steering shaft) is attached to the valve spool by a pin through the stub shaft's outside diameter. The stub shaft's outer end is attached to the torsion bar by a pin. The valve body is pinned to the body cap and torsion bar. Finally, the worm shaft is pinned to the valve body.

b. When the driver turns the steering wheel, the torsion bar twists. The twisting force acts upon the stub shaft. This force, however, is resisted by the vehicle's weight; the force is then transferred from the wheels, through the steering linkage, to the sector gear, to the piston nut, and finally to the worm gear.

c. Because the worm gear is resisting the turning force applied by the driver, the torsion bar twists, causing the stub shaft and valve spool (located inside the valve's body) to rotate. The valve spool's rotation directs fluid to one side of the piston nut, thus assisting the driver in turning the steering wheel. The harder the driver turns the steering wheel, the more the valve opens. The twisting action of the torsion bar allows the driver a feel for the road. The amount the torsion bar can twist is limited by two tangs attached to the upper end of the worm shaft. These tangs fit through slots in the valve body cap and stub shaft.





(**NOTE:** If the engine stalls, or power steering pressure is lost, the slots and tangs will still contact, thus providing manual steering.)

4. The interaction between the valve body and the valve spool (rotating inside the body) opens and closes passages and thereby directs fluid flow.

a. The valve body has two large grooves machined into its outer diameter. In the gear housing, one of the grooves lines up with the inlet pressure port while the other connects with a gear housing passage that directs fluid to the right turn chamber. The grooves are four holes drilled into the inside diameter of the valve body. The grooves are sealed with teflon rings, which are inserted in the valve body's ring grooves.

b. Eight slots are machined into the inside diameter of the valve body. Four are connected to the pressure groove by four of the holes drilled through the valve body. The other four slots are connected to the return port in the gear housing through the valve spool.

c. Within the valve body, four more holes direct fluid through a gear housing passage to the left turn chamber.

d. The valve spool fits very tightly inside the valve body, thus eliminating the need for sealing rings.

e. Four holes in the valve spool line up with the four return slots in the valve body. Fluid flows through the return slots, through the valve spool holes, then through the spool's center, and finally reaches the housing's return port.

f. The valve spool's outer diameter has eight slots. When the steering wheel is moved, these slots open either the right or left holes to the pressure or return slots.

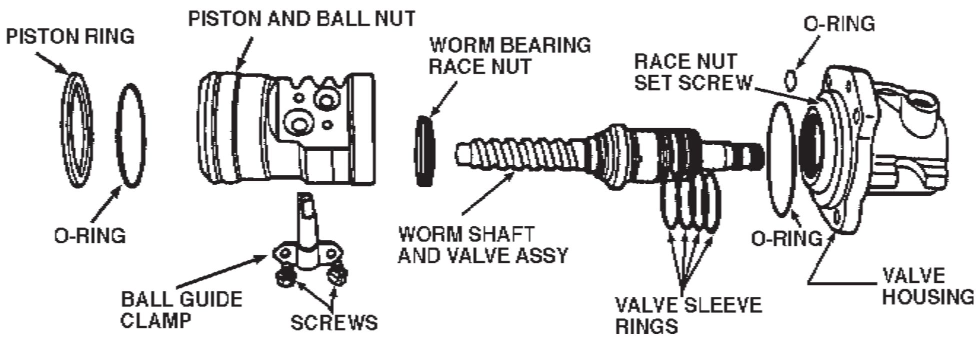
5. Described below is the path that fluid takes through a common rotary valve when the steering wheel is turned either right or left or positioned straight ahead.

a. When the steering is positioned straight ahead, fluid flows from the pump, into the gear inlet port, through the control valve, and back to the pump. No fluid flows to either side of the rack piston, although each side is full of fluid and pressure on both sides of the piston is equal.

b. When the steering wheel is turned right, the torsion bar twists and opens the valve's right turn passage. The left turn passage is closed off to pressure and opened to return oil flow. The piston nut's right turn side is, therefore, pressurized and the piston nut is forced upward. As the nut moves up, fluid is forced out of the left turn side and back to the pump reservoir through the return port.

c. When the steering wheel is turned right, the torsion bar twists and opens the valve's left turn passage. The right turn passage is closed off to pressure and opened to return fluid flow. The piston nut's left turn side is, therefore, pressurized and consequently forces the piston nut downward. As the nut moves down, fluid is forced out of the right turn side and back to the pump reservoir through the return port.

6. In a variation of the rotary valve design, the spool valve is an integral part of the input shaft. The torsion bar connects the stub shaft to the worm. The worm and the valve bode rotate together. Operation of this design is similar to the design of rotary valve previously discussed.



V. Integral spool valve and pivot lever power steering system

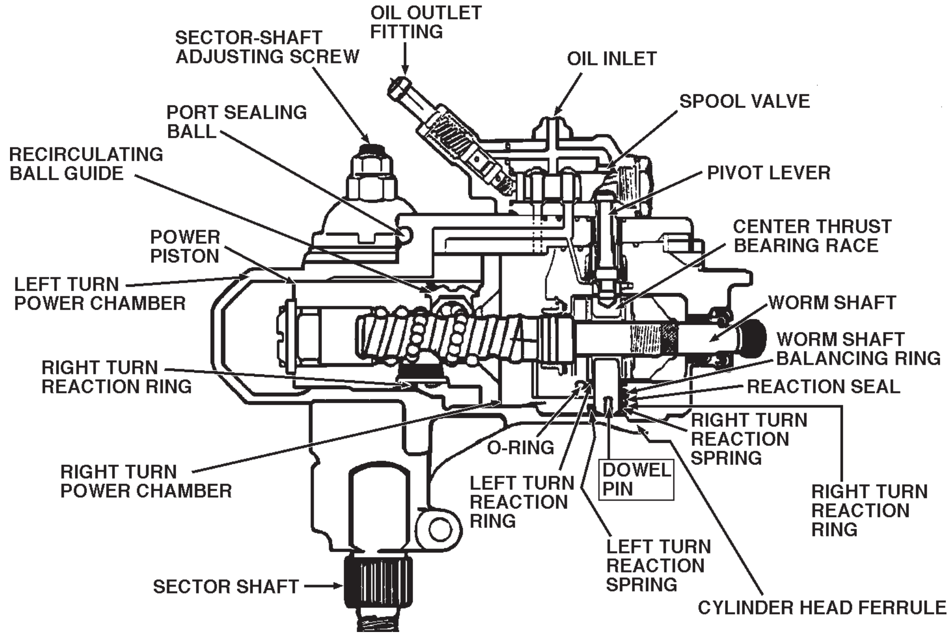
A. The power piston and worm assembly is a recirculating ball type. The piston is integral with the power piston and is double acting. In this design, however, the ball guides are in the form of a plug that screws into the power piston. The worm shaft is supported on the upper end by a bearing installed in the housing head. Two thrust bearings control end thrust.

B. The gear housing encloses the piston nut, worm shaft, and valve assembly along with the sector shaft. The steering control valve is in a separate housing, which is attached to the main gear housing. The operating control for the steering valve, however, is contained in the main housing. This arrangement will be explained later in this lesson.

1. An oil seal is placed at the upper end of the worm shaft in a housing head. The housing head is inserted into the main gear housing. The connection between the housing head and the main housing is sealed by an o-ring. A spanner nut holds the housing head in place.

2. The sector shaft is either supported in the gear housing by a needle bearing or directly mounted on bronze bushings. An oil seal retains the fluid at the sector shaft opening. An opening in the gear housing allows for sector removal. The opening has a cover that is sealed by an o-ring held in place by a spanner nut. The cover also contains the sector adjusting screw.

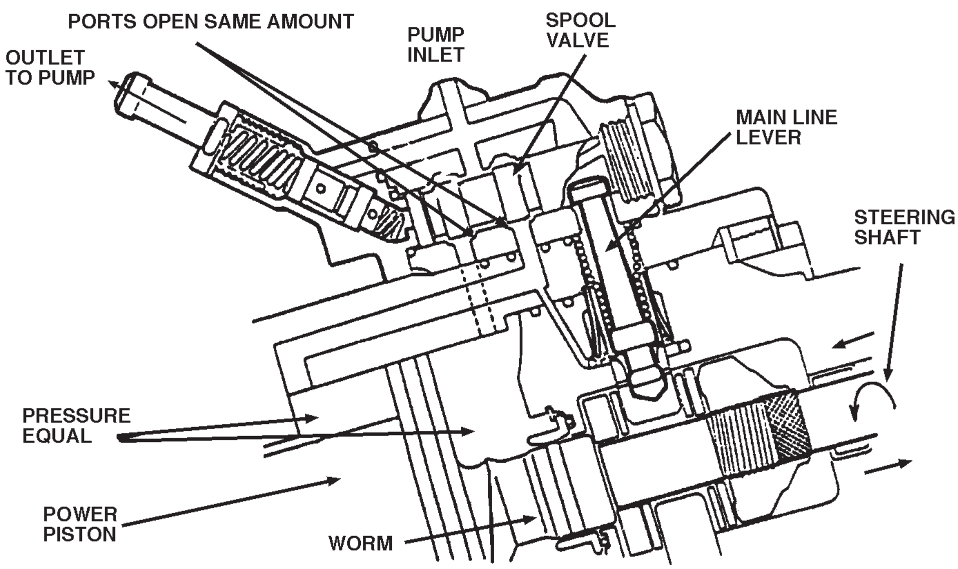
3. The gear housing has a machined bore in which the power piston travels.



C. The sector gear is an integral part of the sector shaft. The design and operation of the sector shaft is similar to that of the sector shaft previously discussed.

D. The valve body assembly consists of two valves within a valve housing and an activating mechanism within the main gear housing.

1. The main valve (a spool valve) slides in a bore with the housing. As the valve moves, it opens or closes passages that admit pressurized fluid to one of the power piston chambers. As the valve opens a fluid passage to one power chamber, it opens another passage to allow fluid to return from the opposing chamber. In the centered position, the valve allows some fluid to both sides of the power piston.



2. The second valve is a pressure control valve, which is located in the outlet (fluid return) side of the control housing. Fluid pressure must overcome spring pressure to open this valve. A pivot lever in the main gear housing extends out of the top of the gear housing and into a groove in the main control valve spool. This lever will move the control valve.

    a. The lower end of the pivot lever fits in a special center thrust bearing race. This race contains a groove, which accepts the pivot lever.

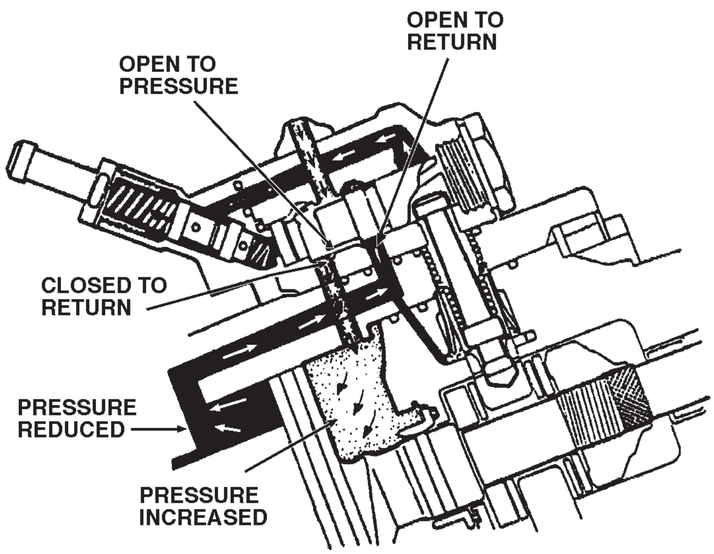
    b. When the driver turns the steering wheel, the turning force applied to the worm results in worm shaft end thrust. The end thrust is carried by two thrust bearings with the special center race between them.

    c. The end thrust causes the center race to move, thus activating the pivot lever and sliding the spool valve.

    d. The end thrust on the worm shaft changes direction as steering direction changes. The pivot lever moves the spool valve forward or backward in response to end thrust, thus opening and closing passages and controlling power assistance.

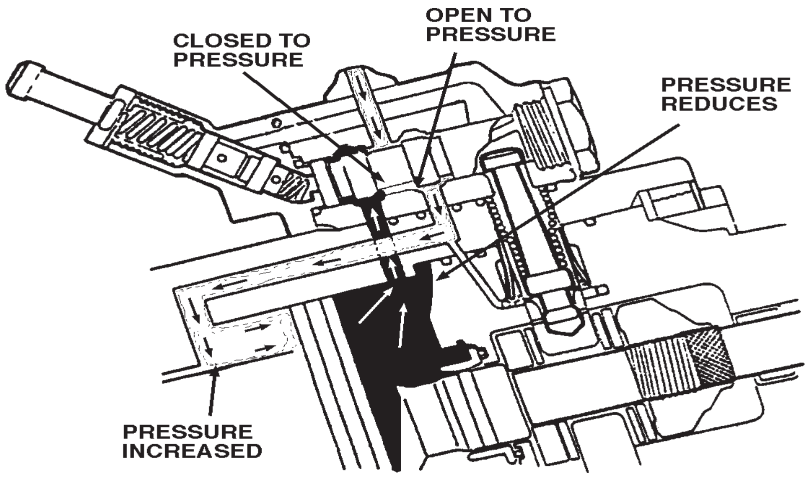
3. Two large cup-shaped springs called reaction springs are placed on either side of the center bearing race. These springs apply pressure to reaction rings and the rings against the race. When the race moves in one direction, the spring on that side is deflected. When pressure on the worm shaft is relieved, the reaction spring resumes its normal shape. The action of the spring helps to center the race and spool valve.

4. When the steering wheel is turned to the right, fluid flows in the pressure port, through the main valve, to the right turn power chamber. As the piston moves toward the front of the gear, fluid flows out of the left turn chamber, and is directed out of the return port and back to the pump. A passage through the cylinder head directs fluid to the rear reaction ring. This action applies pressure to the center race and aids the center spool valve when steering pressure is relieved. A worm balancing ring is added to the right turn reaction area to compensate for pressure imbalance in the system design. This ring adds extra surface area to the right turn reaction area to offset the imbalance.



5. When the steering wheel is turned to the left, fluid flows into the pressure port, through the main valve, and onto the left turn power chamber. As the piston moves toward the front of the gear, fluid flows out of the right turn chamber, and is directed out of the return port and back to the pump. A passage through the cylinder head directs fluid to the rear reaction ring. This action applies pressure to the center race and aids the center spool valve when steering pressure is relieved.

   (**NOTE:** No worm balancing ring is used in the left turn reaction area.)



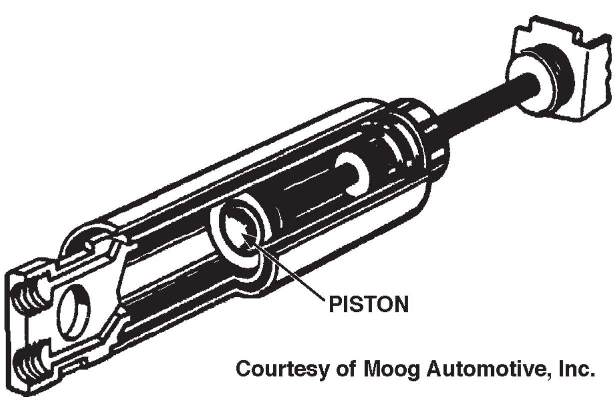
VI. Linkage type power steering

A. Major components of the linkage type power steering system include a manual steering gear, a steering control valve, a double-acting power cylinder, and the power steering pump. No hydraulic power is applied directly to the steering gear; hydraulic pressure is, however, exerted indirectly on the steering linkage via the power cylinder.

B. The steering assembly used with linkage-type power steering is similar to that used with a manual style steering system. The gear ratio is similar to that used in integral power steering systems.

C. The linkage system's power steering pump is similar to pumps used in other power steering designs.

D. The linkage system uses a double-acting power cylinder. Two fluid ports admit or discharge fluid from both sides of the cylinder. The cylinder is mounted under the vehicle from the steering linkage to the vehicle's frame. When the steering wheel is turned, the steering control valve admits fluid to one side of the power cylinder. At the same time, the control valve allows fluid to discharge from the opposing side of the cylinder and return to the pump reservoir.



Courtesy of Moog Automotive, Inc.

E. The linkage system's control valve assembly

1. The control valve housing includes a control valve, centering springs, and a ball socket assembly. Two fluid ports on the valve housing direct fluid to and from the pump. Two additional ports direct fluid in and out of the power cylinder. The valve housing is connected to the pitman arm via a tapered ball stud. The other end of the housing is threaded onto the steering linkage.

2. The control valve itself is a spool type valve, which is held in the centered position by springs. When the valve is in the centered position, fluid is allowed to move from the pump, through the spool, and to both sides of the power cylinder, thus placing equal pressure on both sides of the power piston.

3. When the steering wheel is turned hard enough, the ball socket exerts adequate pressure on the control valve to overcome spring pressure. The valve then shifts, allowing pressurized fluid to flow to one side of the cylinder while opening the other side to fluid returning from the pump. When pressure on the steering wheel is relaxed, the centering springs return the valve spool to the neutral position, and fluid pressure is again equalized on both sides of the cylinder.

AS1-L2-UI

MODULE: STEERING AND SUSPENSION SYSTEMS

FUNCTIONS OF CONVENTIONAL STEERING SYSTEM COMPONENTS

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. Explain how motion is transferred from the worm gear shaft to the sector gear shaft in a manual steering gear.

2. Explain how motion is transferred from the pinion shaft to the inner tie rod ends on a rack and pinion steering system.

3. Explain what occurs with regard to force systems and motion when the input piston is smaller than the output piston.

4. Explain what occurs with regard to force systems and motion when the input and output pistons are the same size.

5. Explain what occurs with regard to force systems and motion when the input piston is larger than the output piston.

6. All power steering pumps function in a very similar manner. When does the distance between the rotor and cam increase the pump?

7. All power steering pumps function in a very similar manner. When does the distance between the rotor and cam decrease the pump?

8. In the integral power steering system using a rotary valve, what components control the fluid flow through the steering gear box?

9. In the integral power steering system using a spool valve and a lever, what device moves the spool valve and lever?

10. Describe two ways in which linkage type power steering differs from integral power steering.

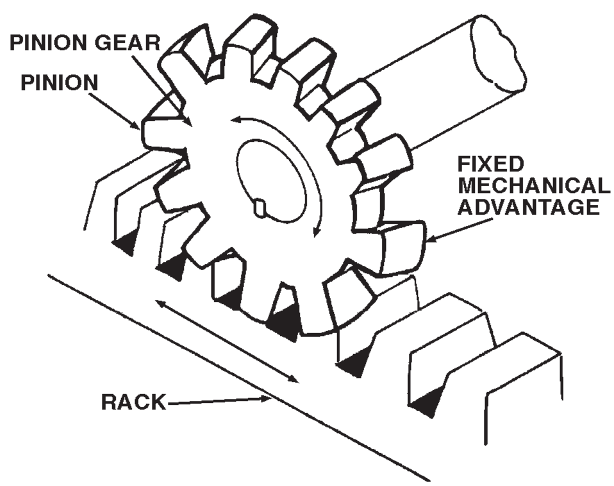
MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT I: STEERING SYSTEM DESIGN

LESSON 3: MANUAL AND POWER RACK AND PINION STEERING COMPONENTS AND OPERATION

I. Manual rack and pinion steering

A. The components of the manual rack and pinion steering system include a pinion gear, which meshes with a rack (a steel bar with teeth cut into one side). The gears are enclosed in a housing made of either aluminum or a combination of steel and aluminum. The pinion gear is attached to the steering wheel through the steering shaft. When the driver turns the steering wheel, the pinion gear rotates and moves the rack laterally. Tie rod assemblies connect the rack to the wheels; the rack movement can then steer the wheels.



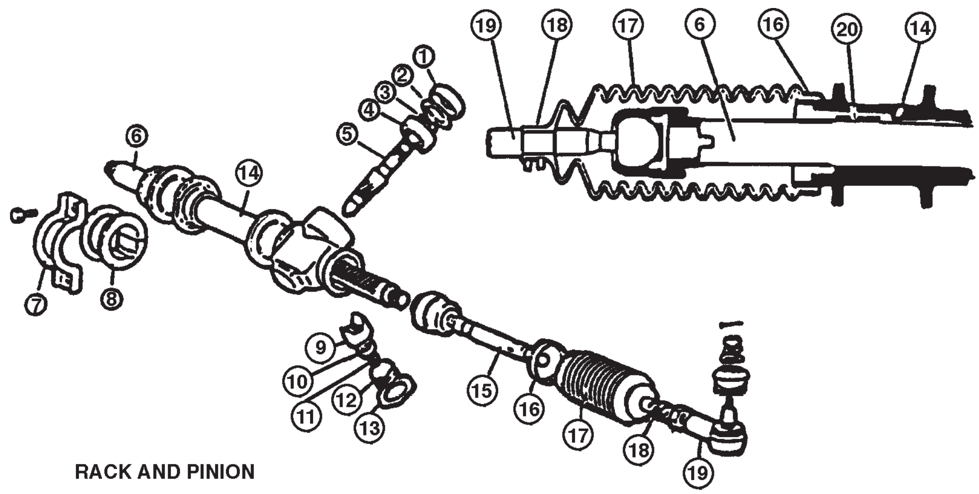
B. The rack is a round steel bar with teeth machined into one side. Nylon or metal bushings at each end of the gear housing support the rack. An adjustable, spring-loaded support bearing is sometimes used at the gear end of the rack. This bearing maintains the proper mesh between the rack and pinion gears. The inner tie rods (a ball socket assembly) attaches to each end of the rack; the tie rods are contained in housings that thread onto the ends of the rack. Bellows boots seal the inner tie rods at each end of the housing.

(**NOTE:** In some rack and pinion systems, the inner tie rods are connected to the center portion of the rack through an opening in the gear housing.)

C. The pinion gear can be a helical (spiral cut) or straight-cut gear. The gear is an integral part of the pinion shaft. Support for the pinion can be provided by nylon bushings and upper and lower thrust bearings (or upper and lower bearings). A preload adjuster sets the proper pinion bearing preload.

D. The gear housing (constructed of aluminum or a combination of steel and aluminum) is usually mounted to the front crossmember under the engine. To reduce noise and vibration, the housing is usually mounted in rubber bushings or grommets. Lubricant in the housing cannot be checked after housing assembly. (A seal at the pinion shaft retains the lubricant.) Rubber or plastic bellows at both ends of the housing protect the inner tie rods and retain the lubricant at the rack ends.

(**NOTE:** The manual rack and pinion system can be positioned in front or behind the engine. When it is positioned behind the engine, it can be located either on the crossmember or mounted on the frame rail.)



RACK AND PINION

1. OIL SEAL
2. SNAP RING
3. SNAP RING
4. BEARING
5. PINION
6. RACK
7. MOUNTING BRACKET
8. MOUNTING RUBBER
9. RACK SUPPORT YOKE
10. CUSHION RUBBER
11. YOKE SPRING
12. YOKE PLUG
13. LOCK NUT
14. GEAR BOX
15. TIE ROD
16. BELLOWS BANK
17. BELLOWS
18. CLIP
19. TIE ROD END
20. BUSHING

II. Power rack and pinion steering

A. The typical power rack and pinion steering unit is an integral system; the steering gear, power cylinder, and control valve are all contained in one unit. Exterior steel lines allow oil flow between the control valve and both sides of the power cylinder. The power steering pump is like those discussed previously in this module. Reinforced rubber hoses connect the pump to ports in the control valve area of the gear housing.

B. Rack construction

1. The rack resembles those used in manual systems. A double-acting power cylinder is installed on the rack. A teflon ring seals the piston to its bore.

2. An inner rack seal holds pressure in the left turn power piston chamber. The outer rack seal (bulkhead seal) holds steering pressure in the right turn chamber.

3. As in manual rack and pinion steering systems, an adjustable, spring-loaded rack bearing maintains the proper tension between the rack and pinion gears.

4. Inner tie rod assemblies attach directly to the rack. As in manual rack and pinion steering, the tie rods may attach to either the ends of the rack or the center of the rack.

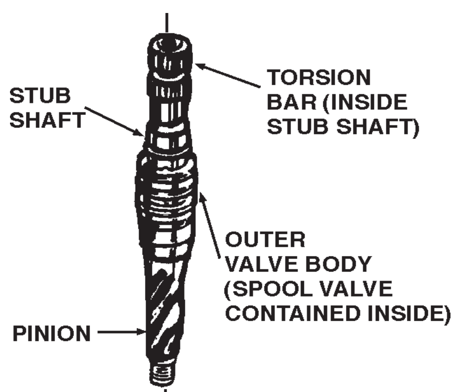
5. Bellows type boots cover the tie rod assemblies and seal out dirt and moisture. Inner and bulkhead rack seals (not bellows boots) retain the fluid within the housing.

6. As in a manual system, the rack's teeth mesh with the pinion teeth. In a manual system, however, the pinion drives the rack right or left. In a power system, hydraulic pressure drives the rack while the pinion assembly controls rack movement.

C. In the power system, the pinion shaft and control valve assembly work in much the same way as the rotary valve assembly in an integral recirculating ball power steering system. The pinion shaft and control valve assembly consist of a stub shaft, a valve spool within the valve body, a torsion bar, and a pinion shaft with a gear.

1. When pressure is applied to the steering wheel, the torsion bar deflects. This deflection changes the relationship between the valve body and valve spool, allowing fluid to flow from the pump to the power cylinder chambers and back.

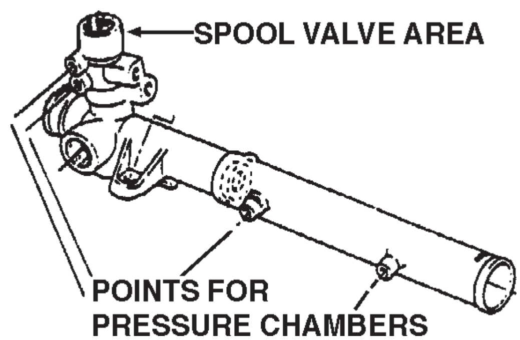
2. When turning pressure on the steering wheel is relaxed, the torsion bar returns the control valve to its neutral position, equalizing pressure on both sides of the power cylinder.



D. Gear housing of the power rack and pinion steering system

1. The gear housing is usually constructed of die-cast aluminum. Both the rack piston and the rotary valve travel in machined bores within the housing. Some housings have a steel insert in which the rack piston travels.

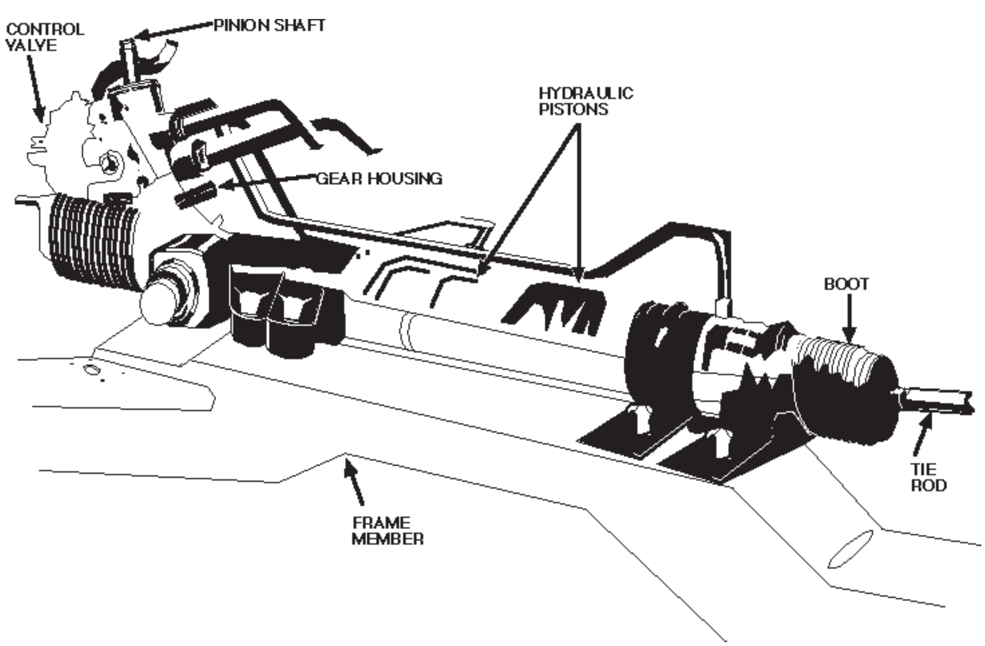
2. Exterior steel lines route fluid to and from the rack pressure chambers. These lines run from ports in the control valve portion of the housing to ports on both sides of the power piston. Two additional housing ports route fluid via hoses to and from the pump.



3. A balancing tube connects both tie rod bellows, balancing air pressure between them. When one bellows is compressed during a turn, the air trapped inside is moved through the balance tube to the opposite bellows.
This is important on power gear assemblies since the inner and outer rack seals in the housing prevent any air flow inside the housing.

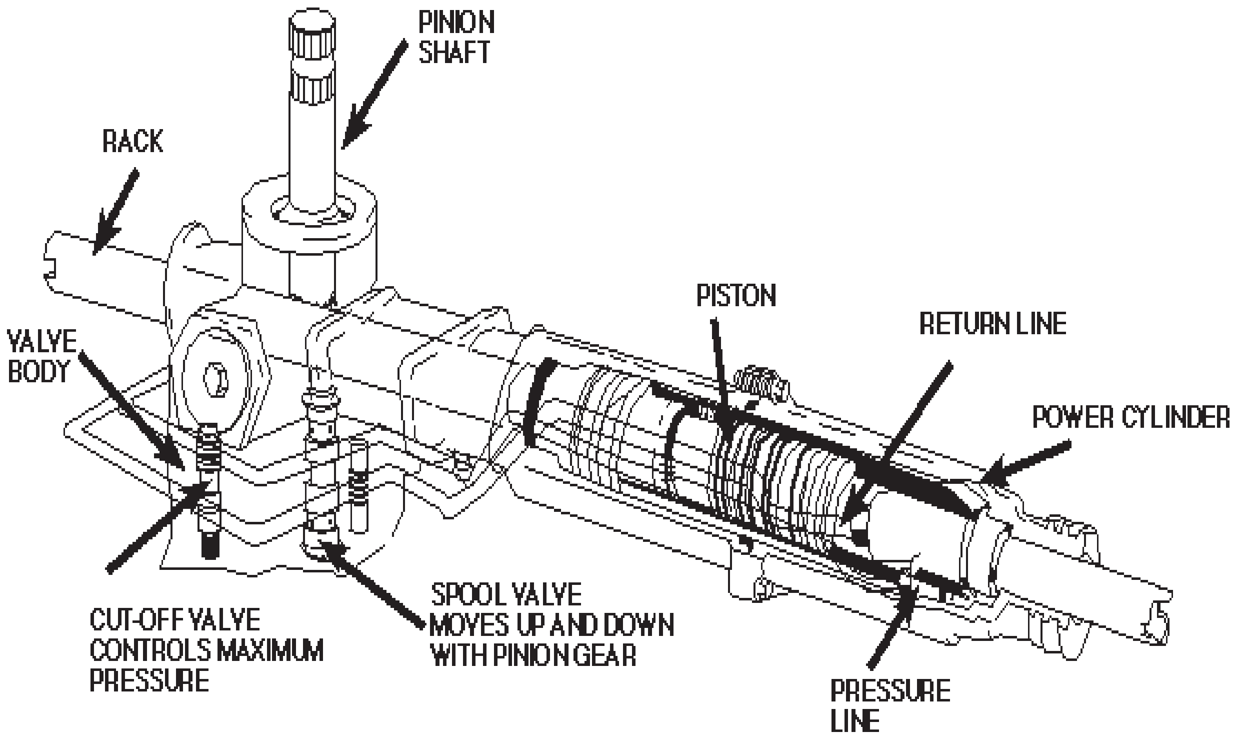
III. Speed-sensitive steering system

A. Some vehicles are equipped with a power steering system that senses the speed of the vehicle and varies the power to the system. The system has an electronically operated solenoid that controls fluid flow into the steering gear valve chamber. As vehicle speed increases, the system provides increased effort.



IV. Proportional rack and pinion power steering

A. Proportional rack and pinion power steering senses vehicle speed and steering load to assure adequate road feel at the steering wheel.



AS1-L3-UI

MODULE: STEERING AND SUSPENSION SYSTEMS

RACK AND PINION COMPONENTS

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. Describe the rack in a power rack and pinion steering system.

2. List five components of the power rack and pinion shaft and control valve assembly.

3. What do bellows boots seal at each end of the rack?

4. Describe the function of the balancing tube between the two bellows boots.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT II: DIAGNOSING STEERING SYSTEM PROBLEMS

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose steering systems and determine needed repairs. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with steering system diagnosis (Competency R1, Unit II Test).

II. Identify the procedures for checking and adjusting manual steering fluid levels (Competency R1, Unit II Test).

III. Identify characteristics of lubricant in manual rack and pinion steering gears (Competency R1, Unit II Test).

IV. Identify procedures for inspecting the condition and level of fluid in conventional power steering and power rack and pinion steering systems (Competency R1, Unit II Test).

V. Identify procedures for bleeding a power steering system (Competency R1, Unit II Test).

VI. Demonstrate the ability to:

a. Inspect and adjust manual steering gear lubricant levels (Competency R1, JS1-L1-UII).

b. Inspect and adjust power steering fluid levels (Competency R1, JS2-L1-UII).

Lesson 2.

I. Identify the procedures for diagnosing leaks in power steering pumps (Competency R1, Unit II Test).

II. Identify the procedures for diagnosing leaks on a conventional power steering gear (Competency R1, Unit II Test).

III. Identify the procedures for diagnosing fluid leaks in power rack and pinion systems (Competency R1, Unit II Test).

IV. Identify the procedures for diagnosing leaks in power steering hoses (Competency R1, Unit II Test).

V. Demonstrate the ability to:

   a. Diagnose fluid leaks in the power steering system (Competency R1, JS1-L2-UII).

Lesson 3.

I. Identify the procedures for general steering gear road test diagnosis (Competency R1, Unit II Test).

II. Identify the causes of and corrections for manual steering gear problems (Competency R1, Unit II Test).

III. Identify the causes of and corrections for power steering gear problems (Competency R1, Unit II Test).

IV. Identify the causes of and corrections for manual rack and pinion steering gear problems (Competency R1, Unit II Test).

V. Identify the causes of and corrections for power rack and pinion steering gear problems (Competency R1, Unit II Test).

VI. Demonstrate the ability to:

   a. Diagnose manual and power steering gear problems (Competency R1, JS1-L3-UII).

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT II: DIAGNOSING STEERING SYSTEM PROBLEMS

CONTENTS OF THIS UNIT

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT II: DIAGNOSING STEERING SYSTEM PROBLEMS

LESSON 1: MANUAL AND POWER STEERING FLUIDS

I. Terms and definitions

A. **Gear lash** — The clearance between two gears.

B. **Power steering fluid** — Petroleum fluid used in power steering systems.

C. **Pull** — The tendency of the vehicle to drift right or left when the steering is held straight ahead.

D. **Shimmy** — The inappropriate back and forth movement of the front wheels.

E. **Steering clunk** — A knocking noise produced by loose steering components.

F. **Steering play** — The distance that the steering wheel can be turned before the wheels respond.

G. **Wander —** The left and right movement of a vehicle. Wander occurs even though the steering wheel is held firmly in the straight ahead position.

II. Manual steering fluid levels

A. Lubricant in the manual steering gear lubricates the internal gear assembly components. The most commonly used fluids are EP (extreme pressure) multi-purpose lubricant or multi-purpose gear oil. Unless it has been contaminated, manual steering gear lubricant does not usually need to be changed. Refer to manufacturer's recommendations before adding fluid.

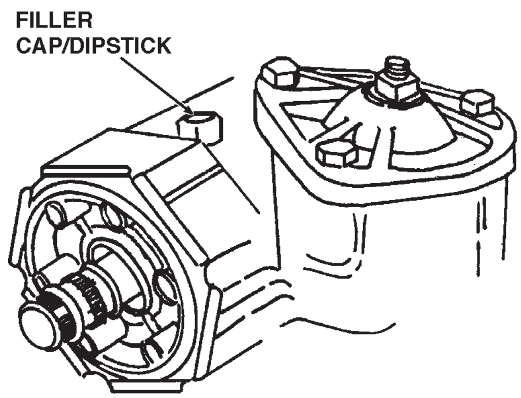
B. A fill hole in the gear housing allows for inspection and adjustment of lubricant levels. Check lubricant according to the procedure outlined below.

1. Clean all dirt and grease from the gear housing fill plug area. Remove the fill hole plug.

2. Remove the sector shaft cover bolt on the opposing end of the gear housing. (**NOTE:** If the gear housing is not equipped with a fill hole, remove upper and lower sector shaft cover bolts.)

3. Using a clean punch or similar tool, clear away any lubricant blocking either of the two holes.

4. Slowly turn the steering to the left and right stops. Lubricant should be visible at both holes. If lubricant is not visible, add lubricant (the type recommended by the manufacturer) to the fill hole. (Add until lubricant is forced out of the bolt hole.) Reinstall and torque the bolts and/or plug to manufacturer's specifications.



III. Lubricant in manual rack and pinion steering gear will usually last the life of the vehicle; therefore, there are no provisions for inspecting the gear's lubricant level. The steering gear should, however, be routinely inspected for leaks. If a leak develops or if lubricant contamination is suspected, the steering gear must be removed, repaired, filled with the proper lubricant, and then reinstalled.

IV. Inspecting level and condition of fluid in conventional power steering and power rack and pinion steering systems

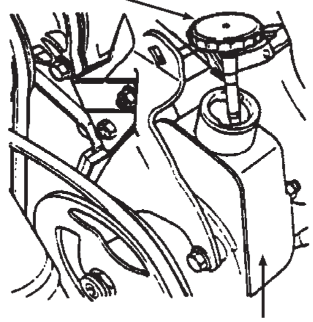
A. Power steering fluid performs the following functions: lubricates internal system components, transfers the force needed to assist steering, and cushions road shocks.

B. Most power steering systems require special fluid. Consult the appropriate service manual before adding fluid. Do not use automatic transmission fluid unless specified by the manufacturer of the vehicle.

C. Fluid inspection

1. Make sure the engine is off and the front wheels are pointed straight ahead. Remove any dirt from around the power steering dipstick.

2. Remove the dipstick and check fluid level.



3. Feel the power steering pump reservoir to see if it is warm to the touch. If the fluid temperature is not warm, the system should be filled to the full cold mark. If the fluid is warm (above 150° F), the system should be filled to the full hot mark.

4. Fill the reservoir to the correct full mark.

5. Replace the dipstick and start the engine. Allow the engine to idle as the steering wheel is slowly turned from lock to lock two or three times.

6. Shut off the engine and repeat steps 1 through 5 until the fluid level reaches the correct full mark.

   (**NOTE:** If the fluid is foamy, allow the vehicle to set a few minutes with the engine off. In extreme cases, the vehicle may have to set for an hour.)

   (**NOTE:** If the dipstick has add and full marks instead of hot and cold marks, the fluid level should be maintained between the add and full marks. If servicing an older system that does not use a dipstick, remove the reservoir cover or lid and adjust the fluid level to the reservoir's full mark.)

7. While performing the above procedure, check fluid for contamination. Metal particles in the fluid indicate a possible pump or gear failure. Milky fluid is an indication of possible moisture contamination. If contamination is discovered, the cause should be corrected and the system should be flushed according to manufacturer's instructions.

V. Sometimes air enters the power steering system during service, causing the system to function improperly and make noise. Air can be removed by bleeding the system according to the procedure outlined below. The following bleeding procedure applies to most vehicles. Check the proper service manual for the exact procedures for the vehicle to be serviced.

   A. Fill the steering reservoir according to the procedure outlined earlier in this lesson.

   B. Start the vehicle engine and run it at idle speed. Without hitting the stops hard, slowly turn the steering wheel from full left to full right several times.

C. Stop the engine. Add fluid if required, and restart the engine.

D. Repeat steps 2 and 3 until all the air is expelled from the system and fluid is at the hot level.

JS1-L1-UII

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND ADJUSTING LUBRICANT LEVELS IN MANUAL STEERING GEARS

Equipment:

Hand tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for adjusting the steering gear lubricant level. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

3. Using the procedure developed in number 2 above, inspect and, if necessary, adjust the lubricant level in the steering gear.

   a. Determine and record the type of lubricant used the the steering gear to be serviced.

b. Be sure to clean the steering gear before removing the fill plug.

c. Record in the space below any leaks you found in the steering gear.

JS2-L1-UII

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND ADJUSTING POWER STEERING FLUID LEVEL

Equipment:

Thermometer
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Determine and record the type of power steering fluid used in the vehicle to be serviced.

   (**NOTE:** An appropriate service manual will list the proper fluid for the vehicle.)

3. Turn the engine off, make sure the wheels are straight, and wipe away any dirt from around the dipstick.

4. Remove the dipstick and determine the level and temperature of the fluid. Record observations.

5. Using the correct fluid, fill the system to the proper level. Replace the dipstick.

6. Start the engine and let it idle while turning the steering wheel slowly from lock to lock.

7. Repeat steps 3 through 6 to ensure that the fluid level is correct. Record observations.

   (**NOTE:** If fluid is foamy, allow the vehicle to set a few minutes with the engine off so that the foam can dissipate. If foam is heavy, the vehicle may have to set for one hour.)

   (**NOTE:** If the dipstick has add and full marks instead of hot and cold full marks, fluid level should be maintained between the add and full marks.)

8. Look for fluid contamination.

   a. Excessive metal particles in the fluid indicate a possible pump or gear failure.

   b. Milky fluid indicates possible moisture contamination.

   c. Record the condition of the fluid.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT II: DIAGNOSING STEERING SYSTEM PROBLEMS

LESSON 2: DIAGNOSING POWER STEERING FLUID LEAKS

I. Power steering pump leaks

A. Following the procedure outlined below, observe the power steering pump carefully to determine the source of the leak.

1. Turn off the engine of the vehicle.

2. Thoroughly clean the pump and the connecting lines. A spray cleaner for parts can make cleaning easier.

3. Carefully examine the pump and lines for leaks.

4. Start engine and bring fluid to operating temperature.

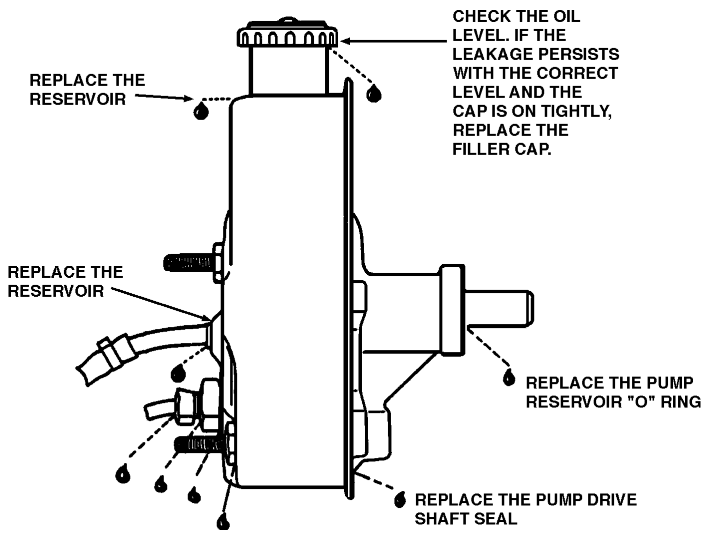
5. Turn wheels all the way to the left and right three or four times. Do not hold the steering wheel against the stops.

6. Turn off engine and once again inspect carefully for leaks.

B. Use the following chart as a guide to leak diagnosis and correction.

SYMPTOM	CAUSE AND CORRECTION
Fluid leaking from around	-Fluid level too high: adjust level the dipstic -Dipstick or dipstick seal missing, loose, or damaged: replace dipstick
Fluid leaking at the pump	-O-ring defective: replace o-ring body -Reservoir dented or damaged: replace reservoir
Fluid leaking from reservoir	-Broken or cracked reservoir: body replace reservoir
Leakage at shaft seal	-Worn or damaged seal: replace seal -Worn shaft bushing: repair or replace pump

SYMPTOM	CAUSE AND CORRECTION
Leak at shaft and seal	-Worn or damaged pump shaft: repair or replace pump
Leak between pump and	-Loose outlet fitting: tighten fitting outlet fitting -Defective outlet fitting o-ring: replace o-ring
Leak at outlet hose fitting	-Loose hose fitting: tighten fitting -Cracked or damaged line fitting seat: replace line -Defective or missing pressure line fitting o-ring: replace o-ring
Leak at return hose connection	-Loosen hose clamp: tighten clamp -Cracked or deteriorated hose: replace hose
Leak through pump housing	-Cracked or porous housing: replace pump



II. Diagnosing leaks on a conventional power steering gear

A. With the vehicle's engine off, inspect the steering gear carefully for leaks and attempt to find the origin of the leak.

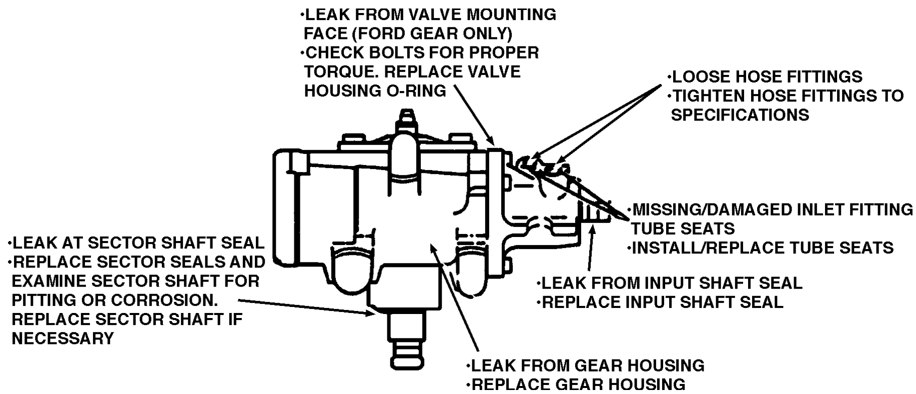
B. Clean the steering gear. A spray cleaner for parts can make cleaning easier.

C. Start the engine and put the wheels through 3 or 4 full left and right turns.

D. Turn off engine and again inspect the pump for leaks.

E. Use the following chart as a guide to leak diagnosis and correction.

SYMPTOM	CAUSE AND CORRECTION
Fluid leakage at hose connection	-Loose fitting: tighten -Damaged fitting seat in gear housing: repair or replace steering gear -Damaged or broken hose fitting: replace hose
Fluid leakage at stub shaft seal	-Seal defective: replace seal
Leakage between stub shaft and torsion bar	-O-ring seal defective: replace seal
Leakage between housing and end plug	-O-ring seal defective: replace seal -Plug loose: repair
Leakage between main housing and control valve housing	-Bolts loose: tighten to specified torque -Defective o-ring: replace o-ring
Leakage around sector shaft ash adjuster nut	-Nut seal bad: replace nut or sealing washer
Fluid leakage between gear housing sector shaft cover	-Bolts loose: torque to specification -Defective o-ring or gasket: replace o-ring or gasket
Leakage at sector shaft seal	-Worn or damaged seal: replace seal
Fluid leakage through gear housing	-Cracked or porous gear housing: Replace housing or gear assembly



III. Diagnosing fluid leaks in power rack and pinion systems

A. With the vehicle's engine off, inspect the steering gear carefully for leaks and attempt to find the origin of the leak.

B. Clean the steering gear. A spray cleaner for parts can make cleaning easier.

C. Start the engine and put the wheels through 3 or 4 full left and right turns.

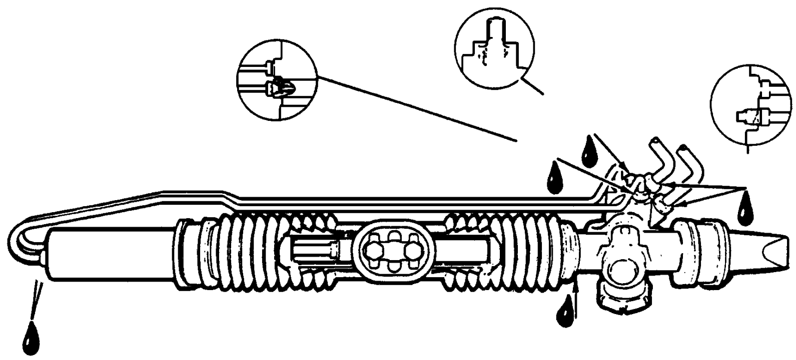
D. Turn off engine and again inspect the pump for leaks.

E. Use the following chart as a guide to leak diagnosis and correction.

SYMPTOM	**CAUSE AND CORRECTION**
Leakage at pinion seal (input shaft)	-Damaged or defective seal: replace seal
Leakage between torsion bar and stub shaft	-Worn or damaged valve assembly: usally not serviceable (consult service manual and replace valve assembly)
Fluid leak at either or both bellows	-Worn or damaged rack seal or worn or damaged gear assembly: remove and disassemble the gear assembly and repair as necessary

SYMPTOM	**CAUSE AND CORRECTION**
Fluid leak at transfer line	-Loose fitting: torque to manufacture's specification -Defective o-ring or plastic seal ring: replace as required -Broken or damaged line: replace line

Fluid leak at hose fitting	-Loose fitting: tighten to specification -Defective o-ring or plastic seal: replace as required
Fluid leak at hose fitting	-Damaged threads: repair or replace hose fitting or housing as required
Leakage through gear housing	-Cracked or porous housing: replace housing or steering gear



IV. Diagnosing leaks in power steering hoses

A. Visually inspect all hoses and determine the source of leakage.

B. If the leak's source cannot be determined, wipe hoses clean, start the engine, and inspect the hoses again.

C. If the leak's source still cannot be determined, have an assistant turn the steering wheel several times to the left and right to increase system pressure; doing so will make the leak easier to detect.

(**NOTE:** Hoses are usually not repairable and must be replaced.)

(CAUTION: **Do not attempt to substitute a fuel hose or any other type of hose for a power steering hose. Use only hoses that have been approved for power steering systems and that have the correct pressure rating. Most other hoses cannot withstand the extreme pressure demands of a power steering system.)**

JS1-L2-UII

MODULE: STEERING AND SUSPENSION SYSTEMS

DIAGNOSING LEAKS IN THE POWER STEERING SYSTEM

Equipment:

Trouble light
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Following the procedure outlined below, raise the vehicle's hood and visually inspect the steering system for leaks.

   a. If the steering system is saturated with fluid, thoroughly clean all suspected components.

   b. Start the engine and make 3 or 4 full lock to lock turns.

   c. Turn the engine off and inspect systems for leaks. Record observations.

   (**NOTE:** In order to detect a slow leak, clean the steering system and drive the car for a distance before inspecting the system.)

3. Recommend steps to repair any leaks found in the steering system. Write the recommendations below.

4. Safely lift and secure the vehicle. Inspect the under-car portion of the steering system for leaks. Record observations below. Recommend steps to correct any leaks. Write recommendations below.

(CAUTION: When lifting a vehicle, always use proper lifting equipment and safety stands.)

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT II: DIAGNOSING STEERING SYSTEM PROBLEMS

LESSON 3: STEERING SYSTEM DIAGNOSIS

I. General steering gear road test diagnosis

(CAUTION: Always obtain the instructor's approval before road testing a vehicle.)

A. Find a suitable location for the road test—a road with light traffic. Perform the road test at a safe speed. Never perform a road test procedure in a manner that might cause loss of vehicle control.

B. While the car is moving, turn the steering wheel in either direction. The wheels should immediately respond. The steering wheel should have no more than two inches of play.

C. Make sure the steering wheel can be turned with minimum effort. The same amount of effort should be required to turn the wheel in both directions.

(**NOTE:** The effort required to turn the steering wheel depends on the steering ratio, tire size, vehicle weight, etc. Take all pertinent factors into consideration when accessing the effort required to turn the wheel.)

D. The steering wheel should turn smoothly from left stop to right stop. There should be no tightness or binding.

E. When released, the steering wheel should tend to return to the straight ahead position.

F. If the vehicle hits bumps or potholes, the steering system should not make any excessive noise.

G. When the steering wheel is held firmly in the straight ahead position, the vehicle should not wander.

II. Troubleshooting charts for a manual steering gear (conventional steering system)

SYMPTOM	CAUSE AND CORRECTION
Front-end wander	-Steering linkage ball sockets worn: replace worn parts -Front end alignment incorrect: set alignment to specifications -Steering gear mounting loose: tighten attaching bolts to proper torque specifications -Excessive sector gear to ball nut lash: adjust according to manufacturer's recommendations

	-Worn steering gear: repair or replace steering gear
Excessive play in steering system	-Front wheel bearings loose: adjust or replace bearings -Loose steering linkage ball socket: replace socket -Excessive sector gear to ball nut lash: adjust lash or replace worn parts -Worm bearings loose or worn: adjust or replace -Loose steering column components: repair as necessary -Worn suspension components: repair or replace as necessary
Excessive steering effort	-Low steering gear lubricant level: check and adjust level -Incorrect steering gear lubricant: drain and install proper lubricant -Steering and suspension needing lubrication: lubricate as required -Low tire pressure: inflate to correct pressure -Steering shaft misaligned or bent: repair steering column as necessary
Poor returnability	-Steering gear adjusted too tight: adjust according to manufacturer's specifications -Incorrect wheel alignment: set alignment to manufacturer's specifications -Binding steering column: repair as necessary -Low or incorrect steering gear lubricant: add or change lubricant

SYMPTOM	CAUSE AND CORRECTION
	-Dry steering or suspension sockets: lubricate as required
Rattle or clanking in steering gear	-Low or incorrect steering gear lubricant: adjust lubricant level or change lubricant -Steering gear attaching bolts loose: tighten to specifica-tions -Pitman arm loose on shaft: tighten to specification -Worn steering shaft or bearings: replace as necessary -Excessive lash between sector gear and ball nut: adjust lash or replace worn parts -Loose or worn thrust bearings: adjust preload or replace as necessary

(**NOTE:** As steering wheel is turned off the high center position, gear lash increases and a slight noise could be produced. This is normal and cannot be eliminated, as lash would then be too tight in the straight ahead position.)

Binding at a given point of turn	-Roughness in worm shaft: replace parts as required

SYMPTOM	CAUSE AND CORRECTION
Required steering effort varies from a left to a right turn	-Uneven tire pressure: adjust to specifications -Worn suspension components: replace as required -Steering gear input shaft not centered: adjust toe to center input shaft
Car pulls to one side	-Tire pressure uneven: adjust pressure to specifications -Wheel alignment incorrect: adjust alignment to specifications -Defective tire: replace tire -Suspension components worn: replace as required

III. Troubleshooting charts for power steering gear (conventional steering system)

SYMPTOM	CAUSE AND CORRECTION
Front end wander	-Steering linkage ball sockets worn: replace worn parts -Front end alignment incorrect: set all angles to specifications -Steering gear mounting loose: tighten attaching bolts to proper torque specification -Excessive lash between sector gear and piston nut: adjust to manufacturer's recommendations -Worn steering gear: repair or replace steering gear
Excessive play in steering	-Steering gear adjustment incorrect: adjust to manufacturer's specifications -Loose or worn wheel bearings: adjust or replace bearings -Steering gear mounting loose: tighten to specification -Tie rod end loose: replace tie rod end -Worn suspension components: replace as necessary

	-Worn steering column components: repair as necessary
Hard steering (excessive effort required)	-Steering gear adjusted too tightly: adjust to specification -Low pressure in steering gear power cylinder due to internal leakage: disassemble and repair -Low or no pump output: repair pump or adjust fluid level -Low tire pressure: adjust to specification -Steering column binding: repair as necessary -Steering linkage or suspension in need of lubrication: lubricate as required

SYMPTOM	CAUSE AND CORRECTION
Poor returnability	-Steering column binding: repair as necessary -Steering gear adjusted too tightly: adjust according to manufacturer's instructions -Incorrect wheel alignment: set alignment to manufacturer's specifications
Gear rattle, clunk, or noise	-Dry steering linkage or suspension sockets: lubricate as required -Valve spool sticking: clean or replace valve spool as necessary -Rack piston nut to worm preload too tight: disassemble and replace balls as required -Excessive sector gear to piston nut lash: adjust to specifications -Gear mounting bolts loose: tighten to specified torque -Worn steering shaft or bearings: repair as necessary -Hissing sound: some hissing is normal when wheel is turned or at a stop. -If hissing is excessive, check for metal contact around flexible coupling between column and gear -Squawking sound: cut or worn control valve dampener o-ring
Steering wheel jerks during turns	-Pump drive belt loose: adjust to specification

No effort required to turn wheel	-Broken torsion bar: replace control valve assembly
Vehicle pulls to one side	-Tire pressure uneven: adjust to specifications -Wheel alignment incorrect: adjust alignment to specifications -Defective tire: replace tire -Steering control valve defective or not adjusted properly: adjust or replace as required -Suspension components worn: replace as required

IV. Troubleshooting charts for a manual rack and pinion steering gear

SYMPTOM	CAUSE AND CORRECTION
Hard steering	-Rack support yoke adjusted too tightly: adjust to specification -Low tire pressure: adjust to specification -Low lubricant level or incorrect lubricant: remove steering gear and install proper fluid -Incorrect wheel alignment: set alignment to specification
Poor returnability	-Steering gear adjusted too tightly: adjust to specification -Lack of tie rod or ball joint lubrication: lubricate as required -Incorrect wheel alignment: set alignment to specifications -Binding in steering column: repair as necessary
Rattle or clunk in steering gear	-Insufficient or improper lubricant: remove rack and pinion steering gear and install correct amount and type of lubricant -Loose mounting bolts: tighten to specification
Binding at a given point in turn	-Rough or worn spot in rack: replace rack and repair as necessary
Excessive looseness in steering	-Wheel bearings loose or worn: adjust or replace bearings -Rack and pinion mounting loose: tighten to specifications -Rack and pinion incorrectly adjusted: make all adjustments according to manufacturer's specifications

	-Loose or worn steering column components: repair as necessary

SYMPTOM	**CAUSE AND CORRECTION**
Front end wander	-Steering linkage ball sockets worn: replace worn parts -Front end alignment incorrect: set alignment to specifications -Rack and pinion mounting loose: tighten attaching bolts to proper torque specification -Improper rack and pinion adjustment: adjust according to manufacturer's recommendations -Worn steering gear: repair or replace steering gear
Vehicle pulls to one side	-Tire pressure uneven: adjust to specifications -Wheel alignment incorrect: set alignment to specifications -Suspension parts worn: replace as necessary

V. Troubleshooting charts for power rack and pinion steering gear

SYMPTOM	**CAUSE AND CORRECTION**
Hard steering	-Internal rack leakage: repair or replace steering gear -Sticking control valve: clean or replace valve -Insufficient pump pressure: repair or replace as necessary -Low tire pressure: adjust to specifications -Steering column binding: repair as necessary -Steering gear adjusted too tightly: adjust to specification -Dry tie rod ends or ball joints: lubricate as necessary
Poor returnability	-Steering gear adjusted too tight: adjust to specification -Lack of tie rod or ball joint lubrication: lubricate as required -Incorrect wheel alignment: set alignment to specifications -Binding in steering column: repair as necessary -Sticking or blocked spool valve: replace valve assembly

SYMPTOM	CAUSE AND CORRECTION
Rattle or clanking noise	-Pressure hose contacting other parts of vehicle: reposition -Loose tie rod end: replace tie rod end -Loose rack mountings: tighten to specifications
Gear noise	-Hissing sound: some hissing is normal when steering wheel is turned to stops or at a stand still -Excessive hissing: replace the control valve -Groan and chatter due to air in system: bleed system
Excessive steering looseness	-Wheel bearings loose or worn: adjust or replace bearings -Rack and pinion mounting loose: tighten to specifications -Rack and pinion incorrectly adjusted: make all adjustments according to manufacturer's specifications -Loose or worn steering column components: repair as necessary
Front end wander	-Steering linkage ball sockets worn: replace worn parts -Front end alignment incorrect: set alignment to specifications -Steering gear mounting loose: tighten attaching bolts to proper torque specification -Improper rack and pinion adjustment: adjust according to manufacturer's recommendations -Worn steering gear: repair or replace steering gear
Vehicle pulls to one side	-Tire pressure uneven: adjust to specification -Wheel alignment incorrect: adjust to specification -Steering control valve not centered: repair or replace as required -Suspension components worn: replace as required

(**NOTE:** The information in all the above troubleshooting charts is general and may not apply to all steering systems. Refer to an appropriate service manual when diagnosing a specific steering system.)

JS1-L3-UII

MODULE: STEERING AND SUSPENSION SYSTEMS

DIAGNOSING MANUAL AND POWER STEERING GEAR PROBLEMS

Equipment:

Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Turn the steering wheel slowly from stop to stop. (If inspecting a power steering system, start the vehicle's engine and run it at an idle.) Respond to the questions below.

   a. Is there binding at any point?
   Yes_____ No_____

   b. Is the same effort required to turn the steering wheel in both directions?
   Yes_____ No_____

   c. Is excessive effort required to turn the wheel?
   Yes_____ No_____

   d. Does the system make any unusual noise?
   Yes_____ No_____

   e. Does the steering wheel jerk during turns? (This question applies to power steering vehicles only.)
   Yes_____ No_____

3. Record the possible causes of any of the problems noted in item 2 above.

4. After obtaining permission from the instructor, drive the car slowly and carefully. Observe if steering wheel returns properly from both left and right turns. Record observations.

5. After obtaining permission from the instructor, drive the car at highway speed and respond to the following questions.

   a. Does the car pull to one side or the other?

      Yes_____ No_____

   b. Does the car wander?

      Yes_____ No_____

6. After obtaining permission from the instructor, drive the car slowly over bumps and rough pavement. Note any gear rattle or clunk. Record observations.

7. Record the possible causes of any of the problems noted in items 4 through 6 above.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT III: INSPECTING AND REPLACING STEERING LINKAGE COMPONENTS

UNIT OBJECTIVE

After completing this unit, the student should be able to identify, repair, and replace worn steering linkage components. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with steering linkage replacement and repair (Competency R7, Unit III Test).

II. Identify the procedures for visually inspecting the linkage (Competency R7, Unit III Test).

III. Identify the procedures for steering linkage inspection (Competency R7, Unit III Test).

Lesson 2.

I. Identify the tools and procedures for breaking tapered fits between steering linkage components (Competency R7, Unit III Test).

II. Identify the procedures for lubricating steering linkage components (Competency R7, Unit III Test).

III. Identify the procedures for removing and replacing a pitman arm (Competency R7, Unit III Test).

IV. Identify the procedures for removing and replacing an idler arm (Competency R7, Unit III Test).

V. Identify the procedures for removing and replacing tie rod ends (Competency R7, Unit III Test).

VI. Identify the procedures for removing and replacing a center link (Competency R7, Unit III Test).

VII. Identify the procedures for replacing a steering dampener (Competency R7, Unit III Test).

VIII. Identify the procedures for replacing a linkage-type power steering control valve (Competency R7, Unit III Test).

IX. Identify the procedures for removing and replacing a linkage power cylinder (Competency R7, Unit III Test).

X. Demonstrate the ability to:

a. Inspect and replace a pitman arm (Competency R7, JS1-L2-UIII).

b. Inspect and replace a center link (Competency R7, JS2-L2-UIII).

c. Inspect and replace tie rods (Competency R7, JS3-L2-UIII).

d. Inspect and replace an idler arm (Competency R7, JS4-L2-UIII).

e. Inspect and replace a steering dampener (Competency R7, JS5-L2-UIII).

f. Inspect and replace a power steering control valve on linkage-type power steering systems (Competency R7, JS6-L2-UIII).

g. Inspect and replace a power cylinder on a linkage-type power steering system (Competency R7, JS7-L2-UIII).

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT III: INSPECTING AND REPLACING STEERING LINKAGE COMPONENTS

CONTENTS OF THIS UNIT

A. Objective sheet

B. Lesson plans

   1. Lesson 1: PROCEDURES FOR INSPECTING LINKAGES

      a. Information outline

   2. Lesson 2: PROCEDURES FOR REPLACING LINKAGES

      a. Information outline

      b. Job sheets

         JS1-L2-UIII: Inspecting and Replacing a Pitman Arm

         JS2-L2-UIII: Inspecting and Replacing a Center Link

         JS3-L2-UIII: Inspecting and Replacing Tie Rods

         JS4-L2-UIII: Inspecting and Replacing an Idler Arm

         JS5-L2-UIII: Inspecting and Replacing a Steering Dampener

         JS6-L2-UIII: Inspecting and Replacing a Power Steering Control Valve on a Linkage-Type Power Steering System

         JS7-L2-UIII: Inspecting and Replacing a Power Cylinder on a Linkage-Type Power Steering System

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT III: INSPECTING AND REPLACING STEERING LINKAGE COMPONENTS

LESSON 1: PROCEDURES FOR INSPECTING LINKAGES

I. Terms and definitions

A. **Castellated nut** — A nut with a series of slots cut into one of its ends. A cotter pin is inserted through the slots to lock the nut in place.

B. **Pickle fork** — A heavy, fork-shaped steel tool used to separate a tapered ball stud from the part to which it is attached.

C. **Pitman arm puller** — A special screw-type puller used to separate the pitman arm from the splined sector shaft.

D. **Self-locking nut** — A special nut that locks in place as a result of the friction created between itself and a bolt or stud.

E. **Taper breaker** — A tool used to remove a tapered stud from a tapered hole. A taper breaker is sometimes referred to as a tie rod press.

F. **Toe** — The compared distance between the extreme edges of the tires at spindle height from the front of the tire to the back of the tire.

(**NOTE:** If the distance measured at the front of the tires is less than that measured at the rear of the tires, the condition is called toe in. The opposite condition is called toe out.)

II. Visually inspecting the linkage

A. Safely lift and secure the vehicle. Clean excessive dirt and grease from all linkage components and inspect the linkage according to the procedure outlined below.

1. Inspect ball socket seals. Look for missing or badly deteriorated seals. Defective seals allow water and dirt to enter the socket assembly, causing premature failure.

2. If linkage is equipped with lubrication fittings or plugs, make sure that they are in place. If fittings are missing, contaminants will enter the socket.

3. Inspect all fasteners. Look for loose or missing nuts and bolts. Make sure that cotter pins are in place. Check for improper fasteners (nuts and bolts).

(**NOTE:** Steering components use specially designed fasteners. Use of fasteners other than those specified by the manufacturer could cause steering failure.)

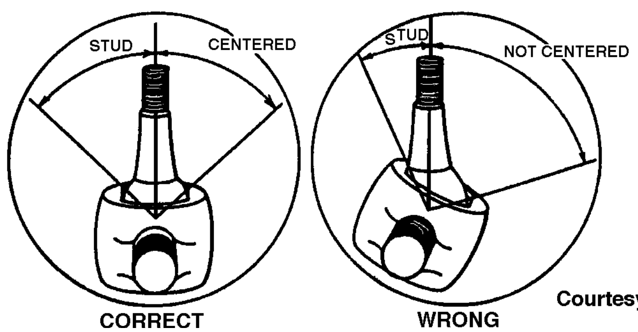
4. Make sure the linkage is not bent, cracked or broken. Also look for improper repairs of previous damage. Note any bent parts that have been straightened or any broken parts that have been welded. All damaged linkage components must be replaced; they should never be repaired.

   (CAUTION: Never attempt to straighten or repair linkage parts with heat applications. Never weld a broken steering linkage part. Never straighten a bent steering linkage. Such procedures can weaken the linkage, causing steering failure.)

B. Procedure for inspecting tie rod assemblies

1. Perform the linkage inspection outlined under item "A" above.

2. Make sure that the sockets are centered. Ball studs need to be centered in their sockets before the sleeve clamps are tightened. If the studs are not centered, they will be locked in position and, therefore, will be unable to swing.



Courtesy of Moog Automotive, Inc.

3. Check tie rod sleeves for rust or distortion. Tie rod sleeves that are badly rusted or distorted should be replaced.

   (**NOTE:** A special tie rod adjusting tool is sometimes used to turn the sleeve during wheel alignment. If the sleeve is badly rusted, it may distort instead of turning.)

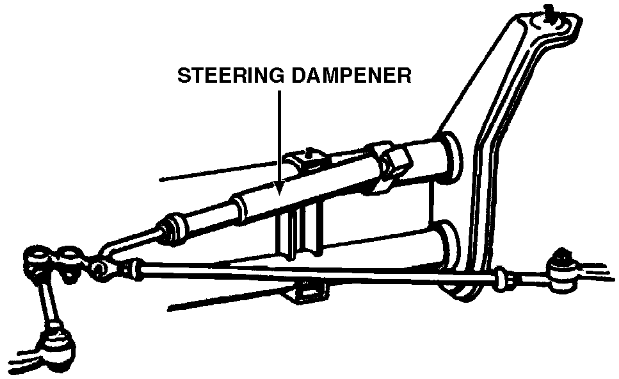
C. Inspect the idler arm for badly deteriorated rubber bushings. Also make sure the idler arm bracket is securely mounted to the frame of the vehicle.

D. Inspect the steering dampener.

1. Look for fluid leakage at the piston rod. A light film or fluid on the housing around the rod is considered normal. If heavy wetness or dripping fluid is found, replace the rod.

2. Inspect the piston rod for pitting and for bends.

3. Inspect the condition of rubber grommets used to mount the rod.



E. Visually inspect the linkage-type power steering control valve for leaks. Also inspect the condition of the hose. Badly deteriorated or leaking hoses should be replaced. Details on hose inspection and replacement are presented later in this module.

F. Inspect the linkage-type power steering power cylinder.

1. Look for fluid leakage at any point along the cylinder. A slight film of oil on the cylinder's piston rod seal is normal.

2. Inspect the piston rod for pitting or damage. If defects are found, the cylinder should be replaced.

3. Inspect the condition of the hoses leading to and from the cylinder.

III. Steering linkage inspection

A. Perform the visual inspection first. Use an appropriate service manual to determine the proper tolerances of a component before passing or failing it.

B. Grasp the pitman arm at the linkage end and shake vigorously. If any movement is detected, isolate the cause.

1. If there is play in the ball socket, the pitman arm or center link may have to be replaced (depending on which part contains the socket).

2. Movement may be the result of looseness between the tapered stud and hole. If the hole is worn, the part must be replaced.

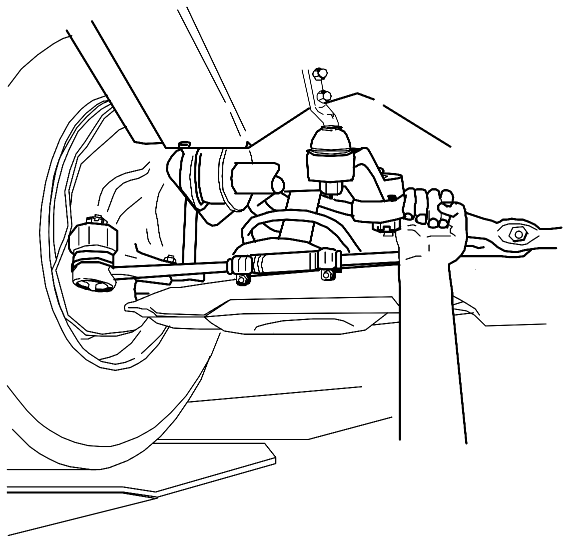
3. If looseness is detected in the steering gear, the gear should be repaired or replaced. Steering gear repair will be covered in a later unit.

C. Idler arms that are not manufactured by General Motors can be inspected by grasping the linkage at the idler arm and applying upward and downward pressure. If the arm moves excessively, it should be replaced. Consult the appropriate service manual for specifications. General Motors recommends the following special testing procedure for their idler arms.

1. Apply a 25 lb. upward and downward force to the idler arm.

2. Measure idler arm movement in both directions. Total movement should not exceed 1/4 of an inch.

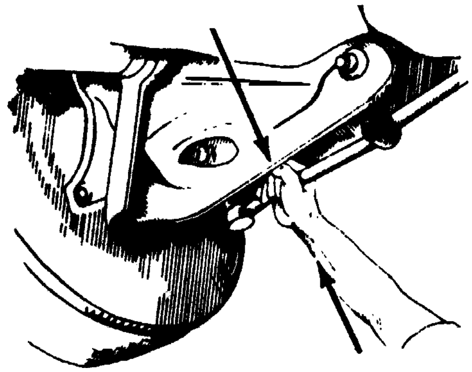
   (**NOTE:** Depending on the car line, the maximum movement may be as little as 1/8 of an inch.)



D. Inspect the tie rods and the center link.

   1. Grasp the tie rod near the ball socket and apply vertical pressure. Excessive movement requires replacement of the loose part. (Be sure to look for movement in the tapered hole before determining if the socket is defective.) Consult the service manual for specifications and more specific procedures.

   2. Twist the tie rod socket back and forth. Replace any sockets that are frozen or rough. Center any sockets that are not centered. (Inner and outer tie rod sockets that are not centered will not twist.)



E. Test for lateral looseness in linkage sockets.

(**NOTE:** Two technicians are required to test linkage sockets for lateral looseness. During the test, the tires must support the total vehicle weight; therefore, the vehicle can be tested either on the floor or on a drive-on hoist.)

1. While an assistant turns the steering wheel back and forth (one to two inches), observe all steering components for excessive looseness.

2. Any component found to be loose should be replaced. Consult the appropriate service manual for the particular specifications.

MODULE: STEERING AND SUSPENSION SYSTEMS

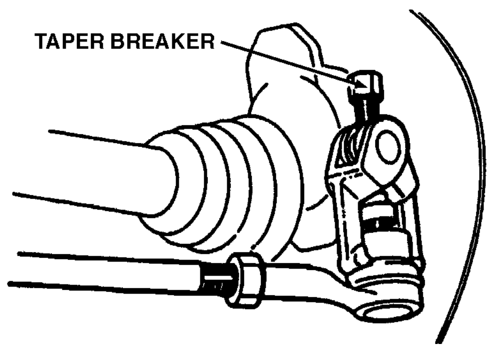
UNIT III: INSPECTING AND REPLACING STEERING LINKAGE COMPONENTS

LESSON 2: PROCEDURES FOR REPLACING LINKAGES

I. Tie rod ends, center links, pitman arms, and other steering linkage components usually use ball studs that fit tightly into tapered holes. Special tools, such as the taper breaking tool and the pickle fork, can be used to break the tapered fit between the stud and hole. Sometimes common hammers work well for this task.

(CAUTION: Always wear eye protection when repairing the steering system. Flying metal chips, which result from hammering, and dirt falling from undercarriage components, are all eye hazards that may be encountered during steering system repair.)

A. The taper breaking tool works like a gear puller, forcing the stud out of the hole with screw pressure. The taper breaking tool will not damage the ball stud.



B. The pickle fork is a heavy, wedge-shaped steel tool, which resembles a pickle fork. The pickle fork is forced between the ball socket and the attaching part. Some pickle forks are designed to be struck with a hammer while others are powered by a pneumatic hammer. As the fork is driven between the two parts, it forces the taper to be broken. The pickle fork disassembles the components quickly, but usually destroys the ball socket.

C. Hammers can also be used to break the tapered fit between the stud and hole. A heavy hammer is rested on one side of the attaching part at the tapered hole. Another hammer is used to strike the part directly opposite the heavy hammer, thus jarring the taper loose. This method often damages the components, and in some situations there is inadequate room to swing the hammer.

(**NOTE:** Never hit the end of the ball stud with a hammer; doing so will damage the ball stud's threads.)

II. Lubricating steering linkage components

A. Steering linkage components should be lubricated at regular intervals. Consult manufacturer's instructions for the proper mileage intervals at which to lubricate linkage components. If no instructions are available, lubricate every 7,500 miles. Though new components are lubricated during assembly, they should also be lubricated again after installation.

(**NOTE:** Always use the factory-recommended chassis lubricant—usually an EP-type lubricant—on steering linkage components.)

B. Procedure for lubricating ball sockets with a hand-operated, low-pressure grease gun

1. Wipe all grease and dirt from the grease fittings.

2. If a plug is found, remove it and install a grease fitting.

3. Snap the gun nozzle onto the fitting and apply lubricant to the socket until the grease seal starts to swell. Wipe excessive grease from the joint.

   (**NOTE:** Forcing grease into the seal after it begins to swell may cause the seal to rupture.)

III. Removing and replacing a pitman arm

(CAUTION: Always wear safety glasses during steering system repairs.)

A. Procedure for removing a pitman arm

1. Safely lift and secure the vehicle.

2. Place a mark on the pitman arm and sector shaft so that the new pitman arm may be installed in the same position.

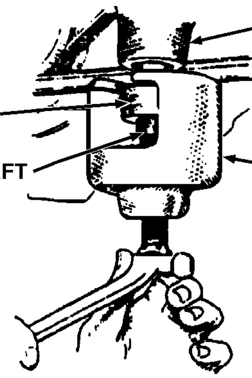
   (**NOTE:** Most pitman arms and sector shafts have a master spline—a spline that is wider than the rest—to prevent improper installation. Adding a mark, however, provides added insurance of proper installation.)

3. Remove the cotter pin and the nut at the linkage end of the pitman arm.

4. Break the taper between the ball stud and the tapered hole.

5. Remove the nut and lock washer from the end of the sector shaft.

6. Use a pitman arm puller or suitable universal puller to remove the pitman arm from the sector shaft. The fit between the splines is very tight, sometimes making removal of the arm difficult.



B. Some pitman arms have a slit in the gear end; a clamp bolt holds the arm tight on the gear shaft.

1. To remove this type of pitman arm, remove the clamp bolt and use a pitman arm puller to separate the arm from the shaft.

2. To install the arm, drive a wedge in the slit, expanding the arm just enough to slide it over the splined sector shaft.

   (CAUTION: **Never use a hammer to beat the pitman arm on or off; doing so may damage the steering gear.)**

C. Procedure for installing the pitman arm

1. Inspect the condition of the tapered hole.

   (**NOTE:** Depending upon its design, the pitman arm may contain a tapered hole or a ball socket. The below procedure applies, of course, to those pitman arms using a tapered hole.)

   a. Wipe any dirt or grit from the tapered hole.

   b. Visually inspect the condition of the hole. If the hole is worn, the arm must be replaced.

   c. Insert the tapered stud in the hole. Only the threaded portion of the stud should protrude. If the stud extends beyond the threads, the worn part must be replaced.

2. Slide the pitman arm onto the sector shaft. Use the reference marks made before disassembly to position the arm.

3. Install the washer and nut on the shaft and torque to manufacturer's specification.

4. Insert the tapered stud in the hole and torque retaining nut to specification.

a. Install cotter pin to lock the nut. If the openings do not line up, tighten the castellated nut to next opening and insert cotter pin.

b. If a self-locking nut is used, the old one should be discarded and a new one of the same design installed.

IV. Removing and replacing an idler arm

(CAUTION: Always wear safety glasses during steering system repairs.)

A. Safely lift and secure the vehicle.

B. Remove the arm from the center link. Idler arms using a bushing arrangement require that the retaining nut be removed and that the arm be tapped or slid free from the center link. If the arm uses a tapered stud, the taper must be broken between the two parts.

C. Note the position of the support bracket; then, unbolt the support bracket from the vehicle frame and remove the arm.

D. Reverse the removal procedure to install the arm.

1. Bolt the bracket to the frame in the same position as before. Some brackets can be reversed but wheel alignment will be changed.

2. Tighten all fasteners to manufacturer's specified torque.

3. Some threaded, bushing-type arms must be measured upon installation.

a. The idler arm bracket must be threaded into the idler arm bushing until a specified measurement is met.

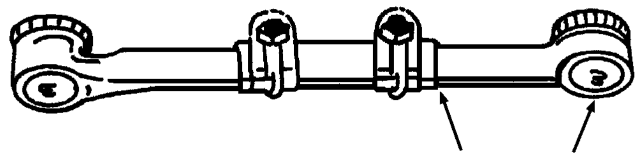
b. Failure to make this measurement will change the toe setting on the vehicle. Specifications for this measurement can be found in an appropriate service manual.

V. Removing and replacing tie rod ends

(CAUTION: Always wear safety glasses during steering system repairs.)

A. Safely lift and secure the vehicle.

B. Measure the distance from the edge of the tie rod sleeve to the center of the tie rod end socket. This measurement will be used to achieve an approximate toe setting during reassembly.



MEASURE THE DISTANCE BETWEEN THE TWO ARROWS

C. Loosen the clamp on the tie rod sleeve. Penetrating oil sprayed on the sleeve and clamp bolts will make disassembly easier.

D. Remove the cotter pin and castellated nut from the end to be replaced.

E. Break the taper on the tie rod end socket.

F. Grasp the tie rod end and thread it out of the sleeve.

1. Remove the tie rod end. If necessary, grasp the tie rod end with locking pliers to facilitate removal.

2. Count the number of times the tie rod must be turned before it is removed from the sleeve. This number will also help position the tie rod during reassembly.

(**NOTE:** The threads of the tie rod end and sleeve may be either right or left handed.)

G. Inspect the condition of the tapered hole as described previously. If worn parts are found, they must be replaced.

H. Reverse the installation procedures to install the tie rod end.

1. Count the number of turns required to thread the tie rod end into the sleeve. Make sure that the number of times the end is turned during installation matches the number of times it was turned during removal. By matching the number of turns, the tie rod end can be positioned exactly as it was prior to disassembly.

2. Center both the inner and outer tie rods in their sockets before tightening the clamps.

3. Tighten all fasteners to manufacturer's specified torque.

I. Following replacement of a tie rod end, the toe should be checked and readjusted. This procedure will be covered in a later unit.

VI. Removing and replacing a center link

(CAUTION: Always wear safety glasses during steering system repairs.)

A. Safely lift and secure the vehicle.

B. Remove fasteners and break the taper on all connecting points.

C. Remove the center link and inspect the condition of the tapered holes as described previously.

D. Install the center link in reverse order of disassembly.

E. Torque all fasteners to manufacturer's specifications and install cotter pins on castellated nuts.

F. Check and adjust toe.

VII. Replacing a steering dampener

(CAUTION: Always wear safety glasses during steering system repairs.)

A. Safely lift and secure the vehicle.

B. If there is any question as to the condition of the dampener, test it according to the below procedure.

1. Disconnect either the frame or linkage end of the dampener.

2. Completely extend and retract the piston rod. An equal amount of resistance to piston rod movement should be felt in both directions. Movement should be smooth, with no binding or skipping.

3. If piston rod does not have the proper resistance, replace it.

C. Disconnect both the frame and the linkage ends and remove the dampener from the vehicle. Inspect all mounting brackets and grommets. Replace any broken or deteriorated hardware.

D. Reverse the installation procedures to install the dampener.

1. Torque all fasteners to manufacturer's specifications.

2. Move the wheels through a full left and right turn and check for smoothness of operation.

E. Steering dampeners or their mountings vary little from manufacturer to manufacturer. The above installation description will apply to most vehicles.

VIII. Replacing a linkage-type power steering control valve

(CAUTION: Always wear safety glasses during steering system repairs.)

A. Procedure for removing a steering control valve

1. Safely lift and secure the vehicle.

2. Clean the control valve to prevent contaminants from entering the system when the control valve fluid lines are disconnected.

3. Mark all fluid lines to ensure proper placement during reassembly.

4. Place a drain pan under the valve assembly and disconnect the fluid lines at the control valve.

    a. Allow the fluid to drain from the lines.

    b. Observe the condition of the fluid. If it appears burnt or contaminated, the system should be flushed. The flushing procedure will be covered in a later unit.

    c. Force fluid in from the system by turning the front wheels to the left and right several times.

    (CAUTION: Turn wheels slowly and stay clear of the open fluid ports and lines. Fluid may be discharged under force.)

5. Loosen the clamp bolt holding the control valve on the steering linkage.

6. Remove the roll pin from the steering linkage through the slot in the control valve sleeve. (The roll pin can be removed with pliers.)

7. Measure from the valve sleeve's lubrication plug to the center of the left inner tie rod end stud. Record this measurement; it will be needed during reassembly.

8. Remove the cotter pin and castellated nut from the ball stud on the control valve.

9. Break the taper between the pitman arm and control valve. Do not use a pickle fork; the fork's pounding force could damage the steering gear or control valve.

10. Thread the control valve from the steering linkage. Count and record the number of turns required to remove the valve.

B. Install the control valve.

1. Thread the new control valve onto the steering linkage. The same number of turns should be used to install the new valve as was needed to remove the old one.

2. Slip the control valve ball stud into the pitman arm.

    a. As was done in the removal procedure, measure the distance from the valve sleeve lubrication plug to the center of the left inner tie rod end stud.

b. If the distance between the lubrication plug and the left inner tie rod end stud do not match the measurement made during removal, take out the tapered stud and turn the valve in or out until the correct measurement is obtained.

c. Once the correct measurement is obtained, install the roll pin through the slot in the control valve sleeve.

d. The sleeve may need to be turned slightly to align with the hole in the steering linkage.

e. The roll pin locks the control valve in place.

3. Torque the sleeve clamp bolt to manufacturer's specification.

4. Install the castellated nut on the tapered stud and torque to manufacturer's specification. Install a new cotter pin. If the nut and the hole fail to align, tighten the nut until alignment is achieved. Never loosen the nut to align the slot and hole.

5. Connect the fluid lines to the control valve. Tighten the hose fittings to the specified torque.

6. Fill the fluid reservoir with a fluid specified by the manufacturer and bleed the system.

7. Inspect the system for leaks.

8. Check and adjust toe. (This procedure will be covered in a later unit.)

IX. Removing and replacing a linkage power cylinder

(CAUTION: Always wear safety glasses during steering system repairs.)

A. Safely lift and secure the vehicle

B. Clean all dirt from the fluid lines going to the power cylinder.

C. Remove the fluid lines at the power cylinder and allow the fluid to drain.

D. Remove the appropriate nut, washer, and rubber insulator to disconnect the cylinder from the vehicle's frame.

E. Remove the cotter pin and castellated nut that retain the cylinder to the steering linkage.

F. Using a taper breaking tool, remove the cylinder from the steering linkage.

G. Install the cylinder in reverse order of removal.

1. Replace any hoses or rubber insulators that are deteriorated.

2. Torque all fasteners to manufacturer's specifications.

3. Fill the fluid reservoir and bleed the system.

4. Inspect for leaks. Correct any leaks found.

JS1-L2-UIII

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING A PITMAN ARM

Equipment:

Hand tools
Ball stud taper breaker
Hoist
Pitman arm puller
Torque wrench
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Safely lift and secure the vehicle.

3. Inspect the pitman arm for wear or damage. Record observations.

4. Following the procedure outlined below, remove and inspect the pitman arm.

    a. Place a mark on the sector shaft and pitman arm to aid in positioning the components during reassembly.

    b. Remove the cotter pin from the castellated nut that attaches the pitman arm to the steering linkage.

    c. Using a taper breaking tool, separate the pitman arm from the steering linkage.

    (CAUTION: If a pickle fork is used to break the taper, the ball socket may be destroyed.)

    d. Remove the nut and lock washer from the sector shaft.

    e. Using the pitman arm puller, remove the pitman arm from the steering sector shaft using the pitman arm puller.

5. Inspect the tapered hole and stud in the pitman arm and steering link. Replace any worn parts. Record observations.

6. Following the procedure outlined below, install the pitman arm.

   a. Refer to the appropriate service manual for torque specifications. Record specifications below.

      Pitman arm to sector shaft ____________

      Pitman arm to steering link ____________

   b. Place the wheels in the straight-ahead position and center the steering wheel. Install the pitman arm on the sector shaft. Use the marks made before disassembly to position the guide properly.

      (**NOTE:** If the pitman arm has a master spline, make sure the arm aligns with it.)

   c. Install the lock washer and nut on the sector shaft and torque to specification.

   d. Attach the pitman arm to the steering linkage. Tighten the castellated nut to specified torque. Continue to tighten the nut until cotter pin can be inserted.

      (**NOTE:** If the opening in the castellated nut does not align with the hole in the stud, continue to tighten nut to next opening and insert cotter pin. Never loosen a nut to align openings; doing so can result in steering system failure.)

   e. If ball socket construction provides a lubrication fitting or plug, lubricate the socket with EP-type chassis lubricant.

   f. If a vehicle uses self-locking nuts instead of castellated nuts, the old nuts should be discarded and replaced with new nuts of identical design.

   g. Turn wheels through a full left and right turn to check for smooth operation. Record observations.

JS2-L2-UIII

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING A CENTER LINK

Equipment:

Ball stud taper breaker
Hand tools
Hoist
Torque wrench
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Safely lift and secure the vehicle.

3. Inspect the center link for wear or damage. Record observations.

4. Following the procedure outlined below, remove and inspect the center link.

    a. Remove cotter pins and castellated nuts from all four connecting points.

    b. Using a taper breaker, separate the center link from the pitman arm, idler arm, and the tie rods.

    (CAUTION: If a pickle fork is used to break the taper, the ball socket may be destroyed.)

5. Inspect the tapered studs and mounting holes of the center link and all attaching arms. Clean excessive grease and dirt from all parts. Replace worn parts. Record observations.

6. Following the procedure outlined below, install the pitman arm.

a. Refer to the appropriate service manual for torque specifications. Record specifications below.

Pitman arm to center link ____________

Idler arm to center link ____________

Tie rods to center link ____________

b. Install the center link, tighten the attaching nuts to the specified torque and install cotter pins.

(**NOTE:** If an opening in a castellated nut does not align with the hole in the stud, continue to tighten the nut to next opening and insert cotter pin. Never loosen the nut to align openings.)

c. If a vehicle uses self-locking nuts instead of castellated nuts, the old nuts should be discarded and replaced with new ones of the same design.

d. Lubricate all ball sockets on the center link with EP-type chassis lubricant if possible.

e. Turn wheels through a full left and right turn to check for smooth operation. Record observations.

f. Lower the vehicle.

g. Check toe and adjust as necessary. See instructor for this procedure.

JS3-L2-UIII

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING TIE RODS

Equipment:

Ball stud taper breaker
Hand tools
Hoist
Safety glasses
Torque wrench

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Safely lift and secure the vehicle.

3. Inspect tie rod assembly for wear or damage. Record findings below.

4. Following the procedure outlined below, remove and inspect the tie rod end.

   a. Loosen the tie rod sleeve clamp bolt on the tie rod end that is to be removed.

      (**NOTE:** If the clamp bolt and the sleeve are rusty, spray them with penetrating oil before disassembly.)

   b. Measure the distance from the edge of the tie rod sleeve to the center of the tie rod end socket. Record this measurement below for use during reassembly.

      Measurement ______________________________

   c. Remove the cotter pin and castellated nut from the ball stud.

   d. Using a taper breaker, separate the tie rod from the center link or steering knuckle.

      (CAUTION: If a pickle fork is used to break the taper, the ball socket may be destroyed.)

f. Thread the tie rod end out of the adjusting sleeve. Count the number of turns required to remove the tie rod end. Record the number below.

Turns required ______________________________

5. Inspect the tie rod sleeve for damage, distortion, bad threads, or severe rusting. If any of the above problems were found, the sleeve should be replaced. Observe the condition of the sleeve. Record observations.

6. Following the procedure outlined below, install the tie rod end.

a. Refer to the appropriate service manual for torque specifications. Record specifications below.

Outer tie rod to steering knuckle __________

Inner tie rod to center link __________

Adjuster sleeve clamp bolt __________

b. Thread the tie rod end into the sleeve, and count the number of turns. Stop when the tie rod end has been turned the same amount of times as recorded in step 4f above.

c. Repeat the measurement made in step 4c above. If necessary, adjust the tie rod in or out to match the previous measurement.

d. Attach the tie rod to the steering knuckle, tighten the nut to specified torque, and install the cotter pin.

e. If a vehicle uses self-locking nuts instead of castellated nuts, the old nuts should be discarded and replaced with new nuts of identical design.

f. Center both the inner and outer tie rod ends in their sockets and tighten the clamp bolts to the specified torque.

g. If the ball socket construction provides a lubrication fitting or plug, lubricate the socket with an EP-type chassis lubricant.

h. Turn the wheels through a full left and right turn to check for smooth operation.

i. Check toe and adjust as necessary. See instructor for this procedure.

JS4-L2-UIII

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING AN IDLER ARM

Equipment:

Ball stud taper breaker
Hand tools
Hoist
Torque wrench
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Safely lift and secure the vehicle.

3. Using a service manual or other information source, locate a procedure for inspecting the vehicle's idler arm. Include any specific tolerances for idler arm wear. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the procedure, inspect the idler arm for wear or damage. Record observations.

4. Using a service manual or other information source, locate a procedure for removing the idler arm from the vehicle. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, remove the idler arm from the vehicle. Record observations.

(**NOTE:** After removing the idler arm, inspect the stud or mounting hole in the center link. If the hole is worn, the center link should be replaced.)

5. Using a service manual or other information source, locate a procedure for installing the idler arm. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, install the idler arm. Record observations.

JS5-L2-UIII

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING A STEERING DAMPENER

Equipment:

Hand tools
Hoist
Torque wrench
Serviceable vehicle
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Safely lift and secure the vehicle.

3. Inspect steering dampener for damage and leakage. Also make sure the dampener is mounted securely. Record observations.

   (**NOTE:** A light film of fluid on the dampener housing is considered normal.)

4. Disconnect one end of the dampener. Extend and compress the dampener, and note any problems. Answer the below questions.

   Was there tightness or binding during dampener travel?

   Yes ________ No __________

   Was there fluid leakage during dampener travel?

   Yes ________ No __________

   Was there skipping (lack of resistance) during dampener travel?

   Yes ________ No __________

   (**NOTE:** If "yes" was the answer to any of the above questions, replace the dampener.)

5. Following the procedure outlined below, remove and install a steering dampener.

a. Disconnect the opposite end of the dampener.

b. Refer to the appropriate service manual for torque specifications. Record specifications below.

Frame end_______________

Linkage end _____________

c. Install the dampener to the vehicle's frame and to the steering linkage. Tighten fasteners to specified torque. Install new cotter pins where used.

d. Turn the wheels through a full left and right turn. Make sure the wheels turn smoothly. Record observations.

JS6-L2-UIII

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING A POWER STEERING CONTROL VALVE ON A LINKAGE-TYPE POWER STEERING SYSTEM

Equipment:

Drain pan
Hand tools
Torque wrench
Safety glasses
Hoist

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Safely lift and secure the vehicle.

3. Inspect the condition of the control valve. Record observations below.

4. Using a service manual or other information source, locate a procedure for removing the control valve. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

    Be certain that the instructor approves the procedure and checks this box before continuing.

    ☐ Instructor Approved

    Following the procedure, remove the control valve. Record observations.

5. Inspect the control valve and answer the below questions.

   Does the control valve show signs of damage or leakage?

   Yes _____ No ______

   Are there tapered holes in the pitman arm?

   Yes ______ No ______

   Are the hoses leading to the control valve in bad shape?

   Yes ______ No ______

   If "yes" was the answer to any of the above questions, describe the proper repair procedures below.

6. Using a service manual or other information source, locate a procedure for reinstalling the control valve. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the procedure, reinstall the control valve. Record observations.

7. Using a service manual or other information source, locate a procedure for adjusting the control valve centering. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the procedure, adjust the control valve centering. Record observations.

8. Start the vehicle's engine and turn the steering wheel completely to the left and right. Note if the power steering system is functioning normally. Record observations.

JS7-L2-UIII

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING A POWER CYLINDER ON A LINKAGE-TYPE POWER STEERING SYSTEM

Equipment:

Ball stud taper breaker
Hand tools
Hoist
Torque wrench
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Safely lift and secure the vehicle.

3. Inspect the condition of the power cylinder. Record observations.

4. Using a service manual or other information source, locate a procedure for removing a linkage-type power cylinder. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, reomve the linkage-type power cylinder. Record observations.

   (**NOTE:** Inspect all hoses during the removal procedure. Any worn, cracked, or leaking hoses should be replaced.)

5. Inspect the tapered hole in the center link and inspect the frame mounting bracket. Record observations.

6. Using a service manual or other information source, locate a procedure for installing a linkage-type power cylinder. The procedure should include specifications on how to determine the type of power steering fluid used in the system. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, install the linkage-type power cylinder. Record observations, including the type of power steering fluid used in the system.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT IV: MANUAL AND POWER STEERING GEAR SERVICE

UNIT OBJECTIVE

After completing this unit, the student should be able to service and adjust non-rack and pinion manual and power steering gears. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the procedures for removing and installing a manual steering gear (Competency R2, Part I of the Unit IV Test).

II. Identify the procedures for disassembling and inspecting a manual steering gear (Competency R2, Part I of the Unit IV Test).

III. Identify the procedures for reassembling and adjusting the steering gear (Competency R3, Part II of the Unit IV Test).

IV. Demonstrate the ability to:

   a. Remove and install a manual steering gear (Competency R2, JS1-L1-UIV).

   b. Disassemble, clean, and inspect a manual steering gear (Competency R2, JS2-L1-UIV).

   c. Reassemble and adjust a manual steering gear (Competency R3, JS3-L1-UIV).

Lesson 2.

I. Identify the procedures for removing and installing a power steering gear (Competency R2, Part I of the Unit UIV Test).

II. Identify the procedures for disassembling and inspecting an integral power steering gear (Competency R2, Part I of the IV Test).

III. Identify the procedures for reassembling an integral power steering gear (Competency R3, Part II of the Unit IV Test).

IV. Identify the procedures for adjusting an integral power steering gear (Competency R3, Part II of the Unit IV Test).

V. Demonstrate the ability to:

a. Remove and install an integral power steering gear (Competency R2, JS1-L2-UIV).

b. Disassemble, clean, and inspect an integral power steering gear (Competency R2, JS2-L2-UIV).

c. Reassemble and adjust an integral power steering gear (Competency R3, JS3-L2-UIV).

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT IV: MANUAL AND POWER STEERING GEAR SERVICE

CONTENTS OF THIS UNIT

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT IV: MANUAL AND POWER STEERING GEAR SERVICE

LESSON 1: MANUAL STEERING GEAR REPAIR

I. Removing and installing a manual steering gear

   A. Procedures for removing a manual steering gear

      1. Remove the two nuts that hold the flexible coupling to the steering shaft. Mark the steering shaft and flexible coupling to aid in proper alignment during installation.

      2. Raise and safely secure the vehicle.

      3. Remove the nut that holds the pitman arm. Mark the pitman arm and sector shaft; then remove the pitman arm using a suitable puller.

      4. Remove the bolts that hold the steering gear to the vehicle frame; then remove the steering gear from the vehicle.

      5. Inspect the vehicle frame in the area where the steering gear is mounted. Look for signs of cracking or elongated mounting holes. Correct all such problems before installing the steering gear.

   B. Reverse the above procedure to install the steering gear. Tighten all fasteners to specified torque.

II. Disassembling and inspecting a manual steering gear

   A. Procedure for disassembling the manual steering gear

      1. Thoroughly clean the exterior of the steering gear with safety solvent.

      2. Place the steering gear in a holding fixture or in a soft-jawed vise.

      3. Center the sector shaft in the center of its travel.

         a. Turn the worm shaft from one stop to the other. (Count the number of turns required to move the shaft from stop to stop.)
         b. Turn the shaft in the opposite direction half as many times as required to reach the first stop.

      4. Remove the sector shaft.

         a. Remove the sector shaft lash adjuster lock nut.

b. Remove the sector shaft cover fasteners. Turn the lash adjuster clockwise to remove the cover. Remove and discard the cover gasket.

c. Slip the lash adjuster screw from the sector shaft slot.

d. Remove the sector shaft from the housing by tapping on the splined end with a soft-faced mallet.

e. Using a suitable tool, pry the sector shaft seal out of the housing. Discard the seal.

5. Remove the worm shaft.

a. Loosen the worm bearing adjuster lock nut with a soft punch.

b. Remove the lock nut and the worm bearing adjuster.

c. Remove the worm shaft and ball nut assembly from the housing.

d. Remove the worm bearing in the gear housing. Also remove the bearing in the bearing adjuster.

6. Disassemble the worm shaft.

(**NOTE:** Some manufacturers recommend that the worm shaft not be disassembled. These manufacturers suggest that the steering gear be serviced as a complete unit.)

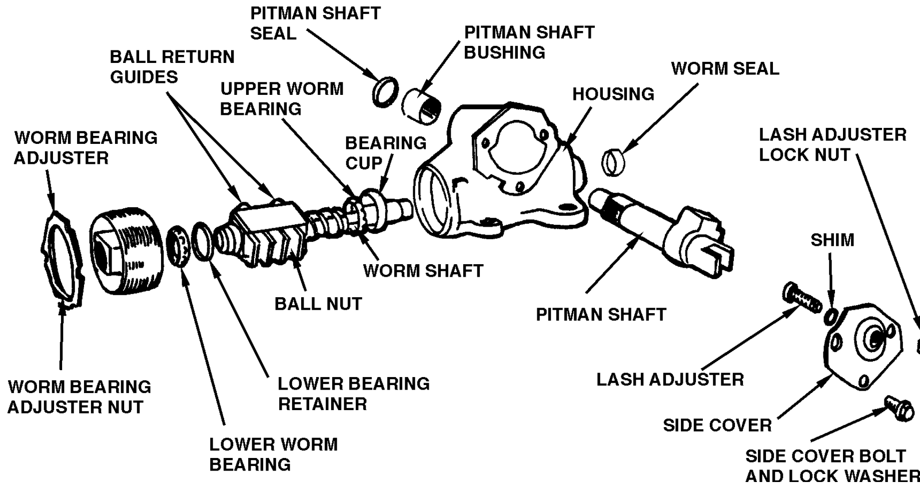
a. Unclamp and remove the return guides from the ball nut.

b. Place a clean cloth on the work bench. Turn the ball nut over and rotate the worm shaft back and forth until all the balls drop onto the cloth.

(**NOTE:** Carefully count the balls removed from the worm shaft. The same number of balls must be reinstalled in each circuit of the ball nut during reassembly.)

c. Remove the ball nut from the worm shaft.

d. Remove and discard the worm shafseal



B. Procedure for inspecting the steering gear

1. Thoroughly clean all parts in solvent and dry them with compressed air.

2. Inspect the worm shaft, the ball nut grooves, and the balls for wear or damage. Replace as required.

3. Inspect the ball nut and sector shaft teeth for wear or damage. Replace both if either is damaged.

4. Inspect the worm bearings for wear or damage. While turning the bearings, feel for any roughness. Any defective bearings must be replaced.

   (**NOTE:** Some worm adjuster bearings are not serviceable; therefore, if a nonserviceable bearing is defective, the entire adjuster must be replaced.)

5. Make sure the sector shaft fits properly between the gear housing bushings and the sector shaft cover. Replace any worn bushings.

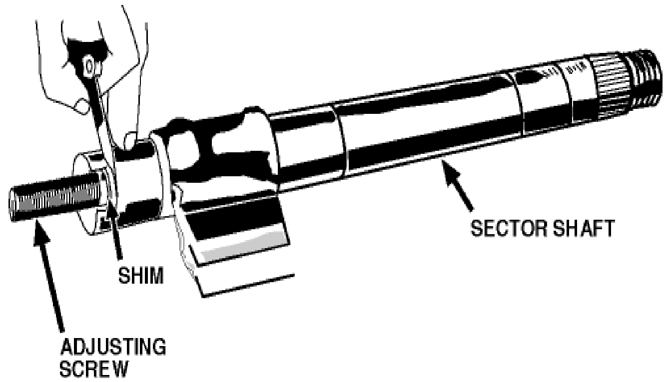
   (**NOTE:** If the bushing in the sector shaft cover is not serviceable, replace the cover.)

6. Inspect the surface of the sector shaft bearing for roughness or wear.

7. Make sure the lash adjuster screw fits properly in the sector shaft's slot.

   a. Make sure the screw head turns freely in the slot.

b. Use a feeler gauge to measure the clearance between the screw head and the bottom of the slot. If the clearance fails to meet the manufacturer's specification, adjust clearance with shims.



8. Inspect the ball guides for damage. Replace if necessary.

9. Inspect the gear housing for cracks or for physical damage. Check the condition of all threaded holes.

III. Reassembling and adjusting the steering gear

A. Using the proper tools, install all bushings and bearings that were removed from the housing.

(**NOTE:** Before the steering gear is assembled, lubricate all seals, bushings, and bearings with the manufacturer's recommended steering gear lubricant.)

B. Place the ball nut over the worm shaft. Position the shaft so that the deep side of the teeth is toward the shaft cover.

1. Install an even number of balls in each ball circuit.

2. Install the remaining balls in the ball guides. The balls should be held in place with grease.

3. Assemble the ball guides on the ball nut.

4. While holding the ball nut, rotate the worm shaft several times to ensure that it is assembled properly and operates smoothly.

C. Install the worm shaft, the worm shaft bearings, and the bearing adjuster in the gear housing. Tighten the adjuster just enough to hold the assembly in place. (Final adjustments will be made later.)

D. Center the ball nut by turning the worm shaft.

E. Adjust worm shaft preload by attaching a torque wrench to the worm shaft and tightening the bearing adjuster to the specified torque. Next, tighten the adjuster lock nut.

(**NOTE:** The procedure for adjusting worm shaft preload will vary from vehicle to vehicle. Consult the proper service manual for the correct procedure.)

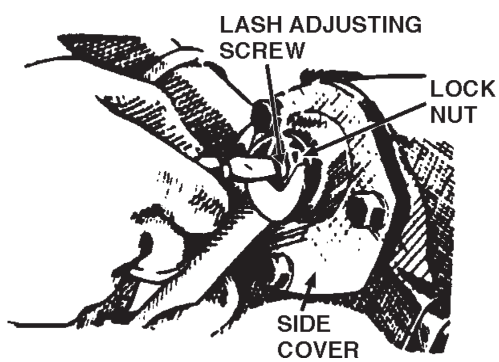
F. Install the lash adjuster screw and place the proper shim on the sector shaft. Slide the sector shaft into the gear housing. Be careful to align the center of the ball nut with the center of the sector gear.

(**NOTE:** Cover the splines and threads of the sector shaft with masking tape; doing so will protect the sector shaft seal during shaft installation.)

G. Place a new gasket on the sector shaft cover. Place the cover over the lash adjuster screw and turn the screw counterclockwise.

H. Tighten the sector shaft cover fasteners to manufacturer's specified torque.

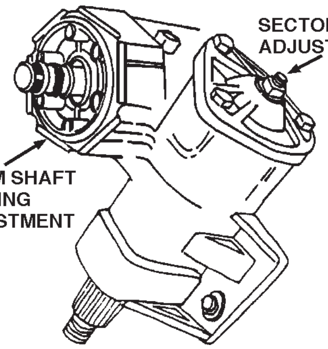
I. Turn the lash adjuster screw until the teeth on the ball nut and sector shaft engage smoothly without binding. Next, install the lock nut (the nut should fit loosely).



J. Using suitable seal drivers, install sector and worm shaft seals.

K. Fill the steering gear with the manufacturer's specified lubricant.

(**NOTE:** Some steering gears use chassis lubricant and should be packed with grease during assembly. Refer to manufacturer's instructions.)



L. Procedure for adjusting overcenter (ball nut to sector gear clearance)

(**NOTE:** Overcenter can be adjusted accurately only after the worm shaft preload is adjusted.)

1. Turn the worm shaft from one stop to the other (count the number of turns required to do so.)

   (**NOTE:** Never allow the steering gear to bump hard against the extreme ends of its travel. A hard bump could damage the ball nut assembly.)

2. Upon reaching the stop, turn the worm shaft back half the number of turns required to meet the stop; doing so will set the steering gear on high center.

3. Adjust the lash adjuster screw until the factory-recommended turning torque on the worm shaft is achieved when passing through the high center range. (This will be a higher torque specification than the one for worm bearing preload.)

4. While holding the lash adjuster screw in position, tighten the lock nut.

5. While slowly turning the steering gear from one stop to the other, check for any roughness or binding. The steering gear should feel tighter as it passes through high center.

JS1-L1-UIV

MODULE: STEERING AND SUSPENSION SYSTEMS

REMOVING AND INSTALLING A MANUAL STEERING GEAR

Equipment:

Hand tools
Hoist
Torque wrench
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. If necessary, safely lift and secure the vehicle.

3. Using a service manual or other information source, locate a procedure for removing the manual steering gear from the vehicle. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the above procedure, remove the steering gear from the vehicle. Record observations.

4. Following the procedure outlined below, inspect the steering gear and related components.

   a. Inspect the gear mounting area of the vehicle frame for cracking or elongated holes. A damaged frame mounting area should be repaired before the gear is reinstalled. Record observations.

   b. Inspect the gear assembly for lubricant leaks or housing damage. Record observations.

   c. Inspect the flexible coupling. If the coupling is worn or damaged, it should be replaced. Record observations.

5. Using a service manual or other information source, locate a procedure for installing the vehicle's manual steering gear. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   (**NOTE:** Be sure to check and, if necessary, adjust the steering gear lubricant level. Refer to JS3-L1-UIV for this procedure.)

   Following the procedure, install the vehicle's manual steering gear. Record observations.

6. Check steering gear operation. Record observations.

JS2-L1-UIV

MODULE: STEERING AND SUSPENSION SYSTEMS

DISASSEMBLING, CLEANING, AND INSPECTING A MANUAL STEERING GEAR

Equipment:

Hand tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Remove the steering gear from the vehicle, if required. Refer to JS1-L1-UIV for this procedure.

3. Using a service manual or other information source, locate a procedure for disassembling the manual steering gear. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   (**NOTE:** After removing the gear, thoroughly clean its exterior with a safety solvent.)

   (**NOTE:** Carefully count the number of balls removed from the ball nut. Be sure not to lose any of the balls.)

   Following the procedure, disassemble the manual steering gear. Record observations.

4. Using a service manual or other information source, locate a procedure for cleaning and inspecting the manual steering gear. Make sure the procedure is appropriate for the make and model of the car to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Fill out the checklist below. If an item is marked "NOT OK", explain the problem and suggest the appropriate steps to correct it.

Following the procedure, clean and inspect the manual steering gear. Fill out the checklist below. If an item is marked "NOT OK", explain the problem and suggest the appropriate steps to correct it.

Worm shaft	OK_____	NOT OK_____
Ball nut	OK_____	NOT OK_____
Ball guides	OK_____	NOT OK_____
Worm bearings	OK_____	NOT OK_____
Gear housing	OK_____	NOT OK_____
Pitman shaft	OK_____	NOT OK_____
Bushings	OK_____	NOT OK_____
Steel balls	OK_____	NOT OK_____
Lash adjuster screw	OK_____	NOT OK_____

JS3-L1-UIV

MODULE: STEERING AND SUSPENSION SYSTEMS

REASSEMBLING AND ADJUSTING A MANUAL STEERING GEAR

Equipment:

Hand tools
Torque wrench
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for reassembling the manual steering gear. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure. During the procedure, be sure to perform the tasks listed below.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

a. Replace all damaged or missing parts as directed by the instruc-tor.

b. Lightly coat all components with the appropriate gear lubricant during assembly. Steer-ing gears using chassis lubricant should be packed during assembly.

c. Tighten all fasteners to factory recommended torque.

d. Fill the steering gear with the factory recommended lubricant.

Following the procedure, reassemble the manual steering gear. Record observations below.

3. Using a service manual or other information source, locate a procedure for adjusting the manual steering gear. Make sure the procedure includes all necessary specifications. Make sure also that the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the procedure, adjust the manual steering gear. Record observations.

4. Turn the worm shaft completely left and right several times. Note any binding or roughness. Record findings below.

5. Reinstall the steering gear on the vehicle. Refer to JS1-L1-UIV for this procedure.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT IV: MANUAL AND POWER STEERING GEAR SERVICE

LESSON 2: INTEGRAL POWER STEERING GEAR REPAIR

I. Removing and installing a power steering gear

A. Procedure for removing a power steering gear

1. Clean dirt from around hose connections. (Dirt can enter the steering gear during removal.) Place a drain pan under the gear.

2. Remove the pressure and return hoses at the gear.

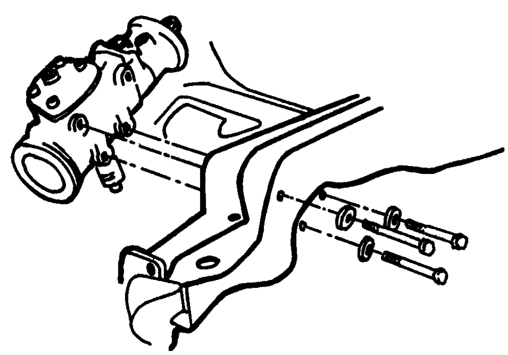
3. Expel the oil from the unit by turning the steering wheel from lock to lock.

4. Disconnect the steering gear at the steering shaft coupling.

5. Safely raise and secure the vehicle.

6. Mark the pitman arm and remove it from the sector shaft.

7. Remove the bolts that hold the gear to the vehicle frame. Remove the steering gear from the vehicle.



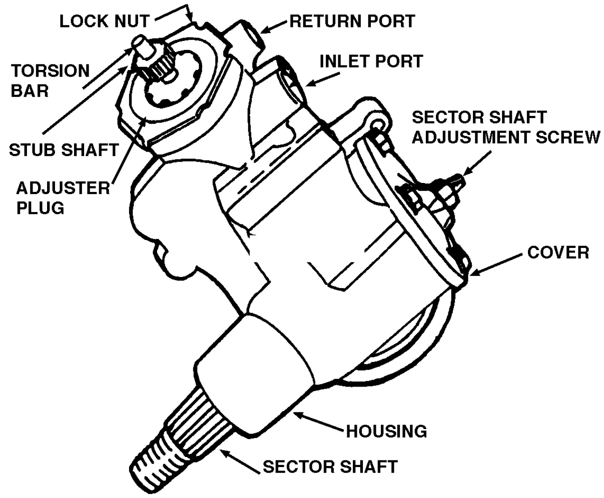
(CAUTION: Power steering gears are very heavy. Care should be used when removing the gear.)

B. Procedure for installing the power steering gear

1. To install the gear, simply reverse the removal procedure. Tighten all fasteners to manufacturer's specified torque.

2. Fill the pump reservoir with factory-recommended fluid and bleed the system.

3. Inspect the steering system for leaks. Repair any leaks found.



II. Disassembling and inspecting an integral power steering gear

(**NOTE:** Integral power steering gear designs vary from vehicle to vehicle. The following procedures are, therefore, very general. Always consult the proper service manual to obtain the correct procedure for a specific vehicle.)

(**NOTE:** Power steering gear repair often requires the use of special tools.)

A. Procedure for disassembling the steering gear

1. Thoroughly clean the steering gear with cleaning solvent.
2. Finish draining the steering gear by placing the hose ports over a drain pan and turning the worm shaft fully to the left and right several times.
3. Secure the steering gear in a holding fixture or mount it in a soft-jawed vise.
4. Loosen the sector shaft lash adjuster screw lock nut.
5. Remove the sector shaft cover bolts. Remove the cover and discard the o-ring.
6. Center the sector shaft in the housing. Free the sector shaft from the housing by tapping the housing's splined end with a soft-faced hammer.
7. Remove the housing end plug retaining ring. Turn the stub shaft in the left turn position until the plug is free of the housing; then remove the plug.
8. Loosen the adjuster plug lock nut and remove the adjuster plug.
9. Remove the piston nut, worm shaft, and lower thrust bearing from the gear housing. A special tool may be necessary to hold the balls in place during disassembly.

10. Remove the stub shaft and control valve from the housing.

    (**NOTE:** On Ford units, the control valve, worm shaft, and piston-nut can be removed together after the valve housing is removed to the gear housing retaining bolts.)

11. If the teflon rings are to be replaced, carefully cut them from the valve body and the power piston.

12. Remove and discard the adjuster plug seal and o-ring. Inspect the roller and thrust bearings in the adjuster plug. If defective, they must be replaced.

B. Procedure for disassembling the control valve assembly

1. Use great caution to ensure that the valve spool does not jam when it is removed from the valve body.

   (**NOTE:** Due to the precise tolerances involved, at least one manufacturer discourages removal of the control unless absolutely necessary.)

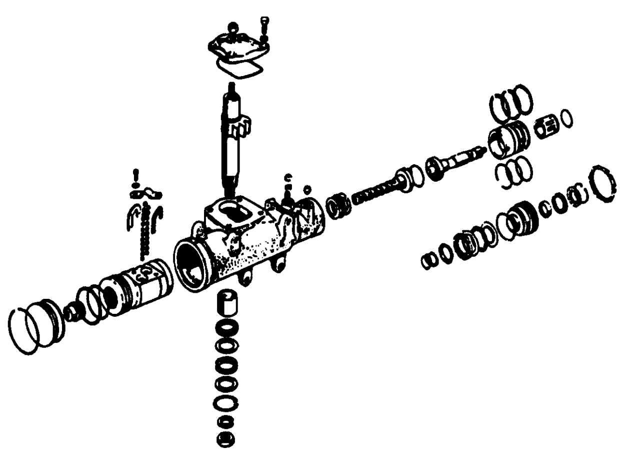
2. When a control valve is disassembled, all teflon sealing rings and rubber o-rings should be replaced with new ones.

C. Procedure for disassembling the piston nut

1. Place piston nut and worm shaft over a clean cloth. Remove the ball return guides.

2. Allow all balls to fall onto the cloth, and carefully count them.

   (NOTE: On Chrysler pivot lever steering gears, the piston nut and worm are not serviceable and must be replaced as a unit.)



D. Procedure for inspecting integral power steering gear components

1. Thoroughly clean all parts in solvent and dry with compressed air.

2. Inspect the sector shaft.

   a. Inspect the shaft bearing surfaces for wear and roughness. Replace bearing if necessary.

   b. Inspect sector gear teeth for wear or roughness. Replace bearing shaft if necessary.

   c. Check cover bushing for wear. Replace cover if necessary.

3. Inspect the worm shaft and piston nut.

   a. Inspect the shaft, piston nut grooves, and balls for roughness and wear. Replace these items if necessary.

   b. Inspect the power piston for wear and roughness. Replace if necessary.

   c. Inspect lower thrust bearing and races for wear or roughness. Replace these items if necessary.

   d. Inspect the outside diameter of the piston nut for wear or scoring. Replace the nut if necessary.

4. Inspect the gear housing.

   a. Inspect the piston bore. If bore is scored or worn, replace the housing.

   b. Inspect the housing for cracks and other damage. Replace the housing if necessary.

   c. Inspect the check valve in the inlet port of the housing. When pressed down and released, the valve should reseat itself against the port connector.

5. Inspect the control valve assembly.

   a. Inspect the valve assembly for leaks between the torsion bar and stub shaft. If leaks are found, replace the assembly.

   b. The spool should rotate freely in the valve body without binding. If the spool binds, replace it.

   c. Inspect the valve body and spool for wear, nicks, and burrs. If these problems are found, replace the assembly.

III. Reassembling an integral power steering gear

A. Assemble the steering gear by reversing the disassembly procedure.

B. Lubricate all seals, bushings, and bearings with power steering fluid before assembly.

C. Install teflon seals by either applying special seal installers or boiling the seals in water for five to ten minutes. The boiling water will soften and expand the seals.

D. If selective balls are used in the piston nut, make sure they are installed in the proper order.

E. Protect the new seal during installation by covering the splined end of the sector shaft with masking tape.

F. Tighten all fasteners to manufacturer's specified torque.

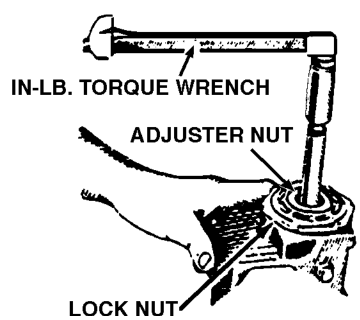
G. Use suitable drivers when installing seals and bearings.

IV. Adjusting an integral power steering gear

(**NOTE:** On some integral power steering gear units, the stub, or worm shaft, must be adjusted before the sector shaft can be installed.)

A. Tighten the bearing adjuster plug until the specified turning torque on the stub shaft is achieved; doing so provides the worm bearings with the proper preload.

(**NOTE:** On Ford steering gears, the bearing adjuster plug should be tightened before the worm assembly is installed in the gear housing.)



B. Adjust power piston nut ball preload.

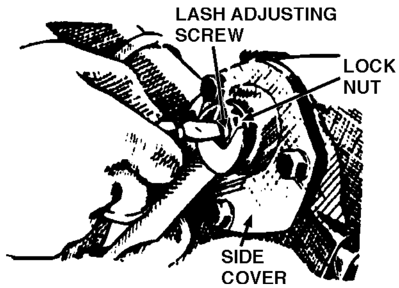
(**NOTE:** Power piston nut ball preload is made on some Saginaw steering gears. Preload is adjusted before the steering gear is assembled. The force needed to turn the piston nut through the high center of the worm groove is measured with a torque wrench. Adjustment is made by changing the ball size.)

C. Procedure for gear lash adjustment

1. Loosen the lash adjuster screw lock nut.

2. Using a torque wrench, turn the lash adjuster until the recommended turning torque is obtained.

3. While holding lash adjuster in position, tighten lock nut.



JS1-L2-UIV

MODULE: STEERING AND SUSPENSION SYSTEMS

REMOVING AND INSTALLING AN INTEGRAL POWER STEERING GEAR

Equipment:

Hand tools
Drain pan
Hoist
Torque wrench
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. If necessary, safely lift and secure the vehicle.

3. Using a service manual or other information source, locate a procedure for removing the power steering gear. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, remove the power steering gear. Record observations.

   (**NOTE:** Before removal, clean all dirt from around the fluid line connections at the steering gear.)

4. Following the procedure outlined below, inspect the gear assembly.

   a. Inspect the gear assembly for fluid leakage and housing damage. Record observations.

   b. Also inspect the gear mounting area of the vehicle frame for cracking or elongated holes. Record observations.

   (**NOTE:** A damaged frame should be repaired before the steering gear is reinstalled. Consult the instructor for the proper procedure.)

   c. Inspect the pressure and return hoses. Record observations.

   d. Inspect the flexible coupling for wear or damage. Record observations.

5. Using a service manual or other information source, locate a procedure for installing the power steering gear. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ **Instructor Approved**

Following the procedure, install the power steering gear. Record observations.

After installation, perform the tasks outlined below.

   a. Make sure all defective parts are replaced.

   b. Fill the steering reservoir and bleed the system.

c. Inspect for leaks and repair any leaks found. Record observations.

d. Lower the vehicle.

e. Check operation of the steering gear. Record observations.

JS2-L2-UIV

MODULE: STEERING AND SUSPENSION SYSTEMS

DISASSEMBLING, CLEANING, AND INSPECTING AN INTEGRAL POWER STEERING GEAR

Equipment:

Hand tools
Drain pan
Vise or holding fixture
Various specialty tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Remove the steering gear from the vehicle, if required. Refer to JS1-L2-UIV for this procedure.

3. Using a service manual or other information source, locate a procedure for disassembling the power steering gear. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   (**NOTE:** Before disassembling the power steering gear, plug fluid ports and thoroughly clean the gear's exterior with a safety solvent.)

   (**NOTE:** Some manufacturers do not service certain steering gear components and do not recommend steering gear disassembly. Closely follow the manufacturer's directions for the vehicle being serviced.)

   Following the procedure, disassemble the power steering gear. Record observations.

4. Using a service manual or other information source, locate a procedure for cleaning and inspecting the vehicle's power steering gear. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor and have the instructor check the box below to indicate his or her approval of the procedure. Following the procedure, clean and inspect the vehicle's power steering gear. Use the below checklist to determine if the components are defective.

(**NOTE:** Thoroughly clean all parts in clean safety solvent and blow dry.)

Control valve assembly	OK_____	NOT OK_____
Piston nut	OK_____	NOT OK_____
Worm shaft	OK_____	NOT OK_____
Stub shaft	OK_____	NOT OK_____
Control valve assembly	OK_____	NOT OK_____
Sector shaft	OK_____	NOT OK_____
Bushings	OK_____	NOT OK_____
Thrust bearings	OK_____	NOT OK_____
Gear housing	OK_____	NOT OK_____
Inlet check valve	OK_____	NOT OK_____
Steel balls	OK_____	NOT OK_____
Ball guides	OK_____	NOT OK_____

If any of the previous components were found to be "NOT OK," suggest appropriate repair procedures.

JS3-L2-UIV

MODULE: STEERING AND SUSPENSION SYSTEMS

REASSEMBLING AND ADJUSTING AN INTEGRAL POWER STEERING GEAR

Equipment:

Hand tools
Torque wrench
Vise or holding fixture
Various specialty tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for reassembling the steering gear. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, reassemble the steering gear. Record observations.

   (**NOTE:** Be sure that all damaged or missing steering gear parts are replaced as directed by the instructor.)

   (**NOTE:** Lightly coat all components with the appropriate power steering fluid during assembly.)

3. Using a service manual or other information source, locate a procedure for adjusting the steering gear. Make sure the procedure is appropriate for the make andmodel of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, adjust the steering gear. Record observations.

4. Turn the worm shaft completely to the left and right several times. Note any binding or roughness. Record observations.

5. Reinstall the steering gear on the vehicle if required. Refer to JS1-L2-UIV for this procedure.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT V: MANUAL AND POWER RACK AND PINION STEERING GEAR SERVICE

UNIT OBJECTIVE

After completing this unit, the student should be able to service and adjust manual and power rack and pinion steering gears. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the procedures for inspecting the tie rods on rack and pinion steering assemblies (Competency R7, Part III of the Unit V Test).

II. Identify the procedures for removing and installing a manual rack and pinion steering gear (Competency R4, Part I of the Unit V Test).

III. Identify the procedures for disassembling and inspecting a manual rack and pinion steering gear (Competency R4, Part I of the Unit V Test).

IV. Identify the procedures for reassembling the manual rack and pinion steering gear (Competencies R4, R5, and R7, Parts I, II, and III of the Unit V Test).

V. Demonstrate the ability to:

   a. Remove and install a manual rack and pinion steering gear (Competency R4, JS1-L1-UV).

   b. Inspect and replace rack and pinion inner tie rods and bellows boots (Competency R7, JS2-L1-UV).

   c. Disassemble, clean, and inspect a manual rack and pinion steering gear (Competency R4, JS3-L1-UV).

   d. Reassemble and adjust a manual rack and pinion steering gear (Competency R4, JS4-L1-UV).

Lesson 2.

I. Identify the procedures for removing and installing a power rack and pinion steering gear (Competency R4, Part I of the Unit V Test).

II. Identify the procedures for disassembling and inspecting a power steering gear (Competency R4, Part I of the Unit V Test).

III. Identify the procedures for reassembling a power rack and pinion steering gear (Competencies R4, R5, and R7, Parts I, II, and III of the Unit V Test).

IV. Demonstrate the ability to:

a. Remove and install a power rack and pinion steering gear (Competency R4, JS1-L2-UV).

b. Disassemble, clean, and inspect a power rack and pinion steering gear (Competency R4, JS2-L2-UV).

c. Reassemble and adjust a power rack and pinion steering gear (Competency R5, JS3-L2-UV).

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT V: MANUAL AND POWER RACK AND PINION STEERING GEAR SERVICE

CONTENTS OF THIS UNIT

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT V: MANUAL AND POWER RACK AND PINION STEERING GEAR SERVICE

LESSON 1: MANUAL RACK AND PINION STEERING GEAR REPAIR

I. Inspecting the inner tie rod

(**NOTE:** Outer tie rods on rack and pinion systems should be inspected in much the same manner as conventional steering linkage outer tie rods are inspected.)

(**NOTE:** The inner tie rod sockets, however, can be difficult to check because they are concealed inside either rubber or soft plastic boots.)

(**NOTE:** The following procedure should be used when the technician wishes to make a quick inspection of the general condition of the inner tie rod. A more thorough inspection procedure is outlined below.)

A. Squeeze the boot until the inner socket is felt.

B. While squeezing the boot, have an assistant either turn the steering wheel back and forth 1/8 to 1/4 of a turn or push and pull on the tires, turning them in and out 1/4 of a turn. If the tie rod feels loose, replace it.

C. Some inner tie rod boots are made of hard plastic, which is impossible to squeeze. To inspect hard plastic rod boots, lock the steering wheel and, using the proper equipment, lift the wheels off the ground.

D. With the vehicle off the ground, turn the wheels in and out while watching for movement in the tie rods. If movement is detected, replace the tie rods.

E. Outlined below is a more thorough tie rod inspection procedure.

1. Remove the inner tie rod boot clamps and slide the boot back to expose the rod.

2. Turn the steering wheel back and forth while the wheels are resting on the ground. Watch the sockets for movement. If movement is detected, replace the rod.

   (**NOTE:** Some manual steering gears will be filled with liquid lubricant which may be lost when the boot is removed. When checking inner tie rods on manual rack and pinion systems that contain liquid lubricant, do not remove the boot unless the entire assembly will be removed or the lubricant can be replaced.)

II. Removing and installing a manual rack and pinion steering gear

A. Procedure for removing a manual rack and pinion steering gear

1. Remove the pinch bolt or roll pin which connects the steering gear to the flexible coupling. The coupling will be located either under the hood or under the instrument panel.

   (**NOTE:** Such items as the steering column boot or a sound deadener panel may have to be removed in order to access the coupling. Some vehicles will have a slip-type coupling that will slide apart as the rack is removed.)

2. Raise and secure the vehicle.

3. Remove the cotter pins and castellated nuts from the outer tie rod ends.

4. Disconnect the outer tie rod ends from the steering arms.

   (**NOTE:** Use a tie rod press and not a pickle fork for this procedure.)

5. Support the steering gear and remove the bolts that attach the steering gear to the vehicle.

6. Remove the steering gear from the vehicle.

   (**NOTE:** On some vehicles, the front tire and wheel assemblies will have to be removed before the steering gear is removed.)

   (**NOTE:** Instead of being removed from underneath the vehicle, some rack and pinion units must be removed through a hole in the inner fender and then taken out of the vehicle's side.)

B. Procedure for installing a manual rack and pinion steering gear

1. To install the rack and pinion gear, reverse the removal procedure.

2. Have an assistant guide the steering gear stub shaft into the flexible coupling as the gear assembly is raised into place.

3. Inspect the condition of the flexible coupling and replace it if it is defective.

4. Inspect the condition of any rubber mounting grommets and replace them as necessary.

5. Tighten all fasteners to the factory-recommended torque.

6. Check toe setting and adjust if necessary.

   (**NOTE:** The procedure for checking toe setting will be covered in a later unit.)

III. Disassembling and inspecting a manual steering gear

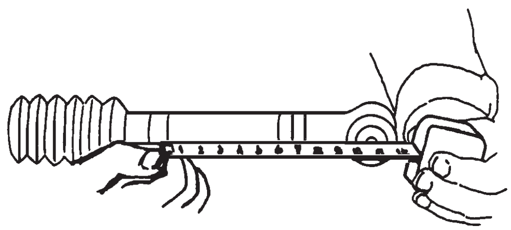
A. Thoroughly clean the exterior of the steering gear with safety solvent. If possible, place the rack and pinion gear in a holding fixture.

(CAUTION: **If the steering gear is clamped in a vise, be extremely careful not to over tighten the vise and destroy the steering gear.)**

B. Disassemble the inner and outer tie rods according to the procedure outlined below.

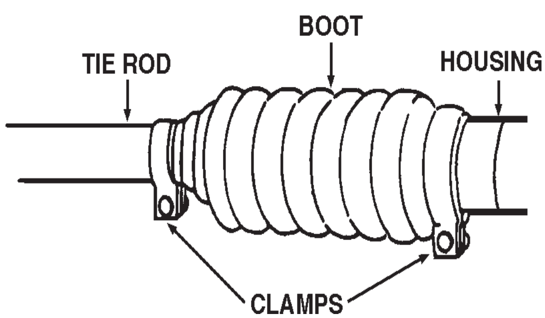
(**NOTE:** Outer tie rods can be replaced without removing the rack and pinion; replacement of inner tie rods, however, may require the removal of the rack and pinion. Consult an appropriate service manual for specific procedures.)

1. Measure from the center of the outer tie rod to the boot retaining groove on the inner tie rod. Record this measurement for both the left and right sides. During reassembly, this measurement will give an approximate toe setting.



2. Loosen the outer tie rod jam nuts; then remove both the outer tie rod and the jam nuts.

3. Remove the four clamps holding the boots to the gear housing and tie rods. These clamps will usually be destroyed during removal.



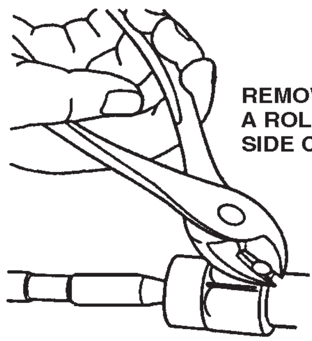
4. Drain the lubricant from the gear housing and remove the boots.

5. The inner tie rods are held in place by one of the four retaining devices listed below. The retaining devices must be removed before the tie rods are removed.

    a. Some inner tie rods are held in place by a soft-steel drill pin driven into a hole located between the inner tie rod and a jam nut. The pin prevents the jam nut from loosening. This pin must be drilled out before the inner tie rod can be removed.

b. Staking is another method of retaining inner tie rods. After the inner tie rods are installed, they are staked or crimped in place. These tie rods can usually be removed with a wrench, but some must be unstaked with a chisel. All replacement rods must also be staked.

c. In some cases, the inner tie rods are locked in with a hollow roll pin, which is driven into the rod. To remove this type of tie rod, drive the roll pin out of the retainer assembly with a punch.



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d. A jam nut is sometimes tightened against the inner tie rod to hold it in place. The jam nut prevents the rod from backing off. The jam nut must be loosened in order to remove the tie rod.

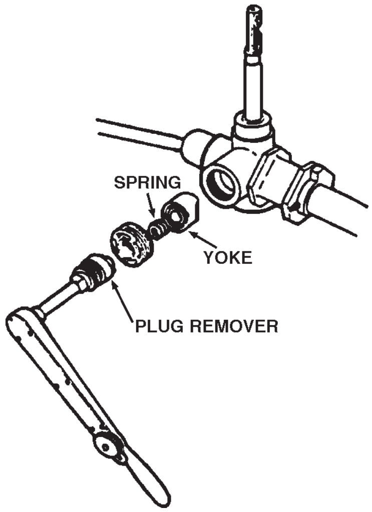
6. After the retaining device is removed, the inner tie rods may be screwed off the rack.

(CAUTION: **As the tie rods are loosened, place an adjustable wrench on the rack to prevent the rack from turning. If the rack should twist, it may damage the pinion.)**

(**NOTE:** If the rack required no other service, the new inner tie rod can be installed according to manufacturer's instructions.)

C. Disassemble rack and pinion according to the procedure outlined below.

1. Remove the yoke plug or cover and the spring and yoke (rack) bearing.



2. Remove pinion oil seal.

3. Remove pinion retainer and then remove the pinion and bearing.

   (**NOTE:** Check the service manual before removing the pinion. To prevent the steering from having an unequal number of turns in the right and left directions, some manufacturers require that a reference mark be made on the rack so that the position of the rack and pinion gears can be determined during unit reassembly.)

   (CAUTION: **Once the pinion is removed, the rack may slide out of the housing.)**

   a. Remove the pinion bearing from the pinion.

   b. On some units the bearing must be pressed off the pinion shaft.

4. Remove the rack from the gear housing.

5. Remove the rack bushing retainers and the housing bushings. A puller may be needed to remove the bushings from the housing. Be careful not to damage the housing when removing the bushings.

   (**NOTE:** Check the service manual before removing bushings. Some manufacturers require that the housing or the entire unit be replaced if the bushings are worn or damaged.)

6. Thoroughly clean all parts in safety solvent and blow them dry.

D. Inspecting the manual steering gear

1. Check boots for deterioration or damage.

2. Check the rack and pinion teeth for wear or damage.

3. Check all bearings and bushings for wear or roughness.

4. Check the housing for cracks or physical damage.

5. Check condition of yoke spring.

IV. Procedures for reassembling the manual steering gear

A. Coat all steering gear components with lubricant prior to reassembly. If the rack uses a lithium-based lubricant, the assembly will need to be packed with grease during reassembly.

B. If rack bushings and retainers were removed, install them in the gear housing.

C. Slide the rack into the housing. Be careful not to damage the bushings. The gear teeth should face the pinion and be parallel to the pinion shaft.

D. Install the pinion and pinion bearings.

1. The rack and pinion must be properly aligned if the steering is to be centered.

2. Depending on the manufacturer's recommendations, align the rack and pinion according to either the reference marks made during disassembly or the measurements given in the service manual.

3. Following the manufacturer's instructions, adjust the pinion bearings. Adjustment procedures will vary, depending on the manufacturer. Some of the more popular methods for adjusting pinion bearings are listed below.

a. A threaded plug, called an adjuster plug, is used to adjust the pinion.

b. Shims are added or removed to obtain the proper adjustment.

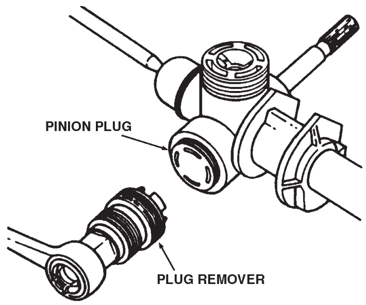
c. Snap rings of different thicknesses are used to obtain the proper adjustment.

E. Install the pinion seal.

F. Install the yoke bearing and adjuster. The yoke adjusting procedures also vary.

1. During adjuster installation, some adjusters merely require that shims be added or removed to achieve the correct preload.

2. During installation of screw adjusters, a plug is screwed into the adjuster until it bottoms. The plug is then backed out a specific amount. The pinion turning torque is checked with a torque wrench. The plug may then be turned in or out as required to achieve the proper torque. The plug is then locked in place with a lock nut.



G. Install the tie rods according to the procedure outlined below.

1. Thread inner tie rod jam nuts and inner tie rods onto the rack.

   a. Tighten tie rods and jam nuts to the factory-specified torque.

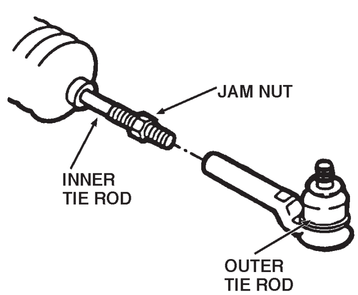
   b. Either install the roll or drill pin or stake the housing.

2. Install boots and clamps over inner tie rod sockets.

   a. If the manufacturer specifies a liquid lubricant, install only one boot and place the rack in a vertical position with the boot on the bottom. Fill the rack housing from the upper end with the correct amount of the specified lubricant. Then install the second boot.

   b. A special tool may be required to install the clamps.

3. Using the measurements taken before disassembly, install the outer tie rods and tighten jam nuts.



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JS1-L1-UV

MODULE: STEERING AND SUSPENSION SYSTEMS

REMOVING AND INSTALLING A MANUAL RACK AND PINION STEERING GEAR

Equipment:

Hand tools
Hoist
Torque wrench
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. When necessary, place the vehicle securely on safety stands or lift with hoist.

   (CAUTION: Always use proper equipment when lifting a vehicle.)

3. Using a service manual or other information source, locate a procedure for removing the manual rack and pinion steering gear. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, remove the manual rack and pinion steering gear. Make sure the procedure includes the inspections outlined below.

   a. Inspect the gear assembly for lubricant leaks or housing damage. Record observations.

   b. Inspect the condition of the flexible coupling and rubber mounting bushings. Replace any worn or deteriorated parts. Record observations.

4. Using a service manual or other information source, locate a procedure for reinstalling the manual rack and pinion steering gear. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐

Instructor Approved

Following the procedure, reinstall the manual rack and pinion steering gear. Make sure the procedure covers the following:

a. Set the toe-in after lowering the vehicle. Ask the instructor for this procedure.

b. Check operation of the steering gear. Record observations.

JS2-L1-UV

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING RACK AND PINION INNER TIE RODS AND BELLOWS BOOTS

Equipment:

Hand tools
Torque wrench
Serviceable vehicle
Hoist
Specialty tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Place the vehicle securely on safety stands or lift it with a hoist.

   (CAUTION: Always use proper equipment when lifting a vehicle.)

3. Using a service manual or other information source, locate a procedure for inspecting the condition of the inner tie rods and bellows boots. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, inspect the condition of the inner tie rods and bellows boots. Record observations.

4. Using a service manual or other information source, locate a procedure for removing the rack and pinion inner tie rods. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

If required, follow the procedure for removing the rack and pinion inner tie rods. Record observations.

(**NOTE:** It may be necessary to remove the rack and pinion unit before removing the inner tie rod and bellows. If so, refer to JS1-L1-UV for the procedure.)

5. Using a service manual or other information source, locate a procedure for reinstalling the rack and pinion inner tie rods. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, reinstall the rack and pinion inner tie rods. Also perform the tasks outlined below.

a. Be sure to retain the inner tie rods in the factory-recommended manner.

b. Tighten all fasteners to specified torque.

c. Set toe-in. See the instructor for this procedure.

d. Check operation of the steering system. Record observations.

JS3-L1-UV

MODULE: STEERING AND SUSPENSION SYSTEMS

DISASSEMBLING, CLEANING, AND INSPECTING A MANUAL RACK AND PINION STEERING GEAR

Equipment:

Hand tools
Drain pan
Vise or holding fixture
Specialty tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Remove the steering gear from the vehicle, if required. Refer to JS1-L1-UV for this procedure.

3. Using a service manual or other information source, locate a procedure for disassembling the manual rack and pinion steering gear. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, disassemble the manual rack and pinion steering gear. Record observations.

4. Using a service manual or other information source, locate a procedure for cleaning and inspecting the manual rack and pinion steering gear. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, clean and inspect the manual rack and pinion steering gear. Use the following checklist to identify any defective components.

Gear housing	OK_____	NOT OK_____
Pinion	OK_____	NOT OK_____
Rack	OK_____	NOT OK_____
Pinion bearings	OK_____	NOT OK_____
Rack bearing	OK_____	NOT OK_____
Bellows boots	OK_____	NOT OK_____
Rack bushings	OK_____	NOT OK_____

Suggest appropriate procedures for correcting any problems identified in the above chart.

JS4-L1-UV

MODULE: STEERING AND SUSPENSION SYSTEMS

REASSEMBLING AND ADJUSTING A MANUAL RACK AND PINION STEERING GEAR

Equipment:

Hand tools
Torque wrench
Vise or holding fixture
Specialty tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for reassembling the manual rack and pinion steering gear. Make sure the procedure is appropriate for the make

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ **Instructor Approved**

   Following the procedure, reassemble the manual rack and pinion steering gear. Record observations.

   a. Make sure that all damaged or missing parts are replaced as directed by the instructor.

      (**NOTE:** Lightly coat all components with the appropriate gear lubricant during assembly. Steering gears using lithium-lubricant should be packed during assembly.)

   b. Tighten all fasteners to factory-recommended torque.

   c. Fill the steering gear with the factory-recommended lubricant.

3. Using a service manual or other information source, locate a procedure for adjusting the manual rack and pinion steering gear. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the procedure, adjust the manual rack and pinion steering gear. Record observations.

4. Turn the pinion shaft through a couple of full left to right turns. Note any binding or roughness. Record observations.

5. Reinstall the steering gear on the vehicle, if required. For this procedure, refer to JS1-L1-UV.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT V: MANUAL AND POWER RACK AND PINION STEERING GEAR SERVICE

LESSON 2: POWER RACK AND PINION STEERING GEAR REPAIR

I. Removing and installing a power rack and pinion steering gear

A. Procedure for removing a power rack and pinion steering gear

(**NOTE:** Determine the source of any fluid leaks before removing the power rack and pinion gear; doing so will help in diagnosing the unit as it is disassembled.)

1. Remove either the pinch bolt or roll pin that connects the steering gear to the flexible coupling. The coupling may be located under either the hood or the instrument panel, depending on the vehicle's design. Items such as the steering column boot or the sound deadening panel must be removed to gain access to the coupling.

   (**NOTE:** Some vehicles have a slip-type coupling that slides apart as the rack is removed.)

2. Raise and secure the vehicle.

3. Remove the cotter pins and castellated nuts from the outer tie rod ends.

4. Disconnect the outer tie rod ends from the steering arms.

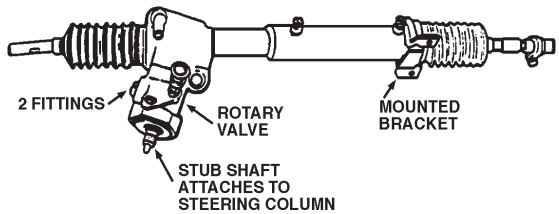
   (**NOTE:** Use a tie rod press and not a pickle fork to remove the tie rod ends.)

5. Place a drain pan under the steering gear and disconnect the pressure and return fluid lines at the steering gear. Plug both the lines and the fluid ports on the gear housing.

6. Support the steering gear and remove the bolts attaching the steering gear to the vehicle.

7. Remove the steering gear from the vehicle.

   (**NOTE:** On some vehicles, the front tire and wheel assemblies must be removed before the steering gear is removed.)
   (**NOTE:** Some rack and pinion units must be removed through a hole in the inner fender and then taken out of the vehicle's side.)



B. Procedure for installing a power rack and pinion steering gear

1. To install the rack and pinion gear, reverse the removal procedure.

2. Have an assistant guide the steering gear stub shaft into the flexible coupling as the gear assembly is raised into place.

3. Inspect the condition of the flexible coupling and replace it if defective.

4. Inspect the condition of any rubber mounting grommets and replace them as necessary.

5. Inspect and replace hoses that are deteriorated or leaking.

6. Tighten all fasteners to the factory-recommended torque.

7. Fill the fluid reservoir with the factory-recommended fluid and bleed the system as described in Unit II of this module.

8. Inspect for leaks and make repairs, if necessary.

9. Check toe-in setting and adjust if necessary.

(**NOTE:** The procedure for checking toe-in will be covered in a later unit.)

II. Disassembling and inspecting a power steering gear

A. Thoroughly clean the exterior of the steering gear with a safety solvent.

B. If possible, place the rack and pinion gear in a special holding fixture.

(CAUTION: If the steering gear is clamped in a vise, be extremely careful not to overtighten the vise and destroy the steering gear.)

C. Disassemble the inner and outer tie rods.

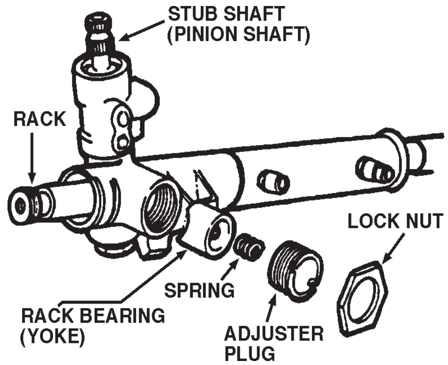
(**NOTE:** Tie rods on power rack and pinion units are serviced in the same manner as those on manual steering units. Refer to Lesson 1 of this unit for specific service procedures.)

(**NOTE:** A breather tube will connect both bellows boots. Mark the position of the breather tube on the gear housing before disassembly. The marks will be useful during reassembly.)

D. Disassemble the rack and pinion according to the procedure outlined below.

(**NOTE:** Each manufacturer of power rack and pinion steering units uses different designs. Though all rack and pinion units operate in a similar manner, service procedures vary. Special tools, such as pullers or seal installers, may be required to service some units. The procedure outlined below is very general. Consult the appropriate manual for specific procedures.)

1. Loosen the adjuster plug lock nut and remove the adjuster plug, the spring, and the rack bearing.



2. Remove the pinion shaft and control valve assembly according to the procedure outlined below.

   a. Rotate the pinion shaft until the rack is centered in the housing. Mark the housing where flat on the stub shaft is located. This mark will be used for reference during reassembly.

   b. Remove the stub shaft retaining ring.

   c. Remove the dust cover and lock nut from the pinion shaft.

   d. Remove the stub shaft seal.

   e. Remove the pinion and valve assembly.

   f. Remove the old sealing rings from the control valve. Be careful not to damage the control valve.

3. Remove the rack from the housing.

   (**NOTE:** Mark the rack with a position location reference so that the rack can be correctly positioned during reassembly.)

   a. Remove the bulkhead retaining ring.

b. Remove the rack and bulkhead.

c. Remove the inner rack seal from the housing.

d. Remove the piston ring from the rack.

4. Disassemble the housing.

a. Remove the pinion bearing from the housing.

b. Remove the pinion bushing and seal.

c. Mark the position of the breather tube for reassembly.

d. Remove the breather tube.

e. Remove the cylinder lines and o-rings.

E. Inspect the power steering gear according to the procedure outlined below.

1. Clean all parts in safety solvent and blow dry.

2. Inspect the gear housing.

a. Inspect the hoses for cracks and porosity.

b. Inspect the control valve bore for wear or scoring.

c. Inspect the rack piston bore for wear, pitting, or scoring.

d. Make sure all fluid passages are open and clean.

e. Inspect the condition of the cylinder lines and fittings.

3. Inspect the rack.

a. Inspect the rack teeth for chipping or wear.

b. Inspect the piston for nicks or burrs.

c. Inspect all seal and bearing surfaces for roughness or wear.

d. Inspect the tie rod threads on the rack for wear. Make sure threads are not stripped.

4. Inspect the valve and pinion assembly.

a. Inspect the pinion gear for wear or chipping.

b. Inspect the valve spool for wear or nicks and scratches. Light scratches may be polished with crocus cloth.

c. Inspect shaft bearing and seal surfaces for wear or scoring.

(**NOTE:** With the exception of the sealing rings on the valve spool, the valve and pinion assembly is serviced as a complete unit.)

5. Inspect all bushings and bearings for wear or roughness and replace them if necessary.

III. Reassembling a power rack and pinion steering gear

(**NOTE:** Each manufacturer of power rack and pinion steering units uses different designs. Though all rack and pinion units operate in a similar manner, service procedures vary. Special tools, such as pullers or seal installers, may be required to service some units. The procedure outlined below is very general. Consult the appropriate manual for specific procedures.)

(**NOTE:** Coat all parts with power steering fluid before reassembly.)

A. Install the cylinder tubes in the gear housing.

1. Use new o-rings on the tubes.

2. Tighten the fittings to specified torque. Be careful not to crossthread or overtighten the fittings in the aluminum housing.

B. Install the upper pinion bushing and a new pinion seal in the gear housing.

C. Install the lower bearing of the pinion shaft and the retainer in the gear housing.

D. Carefully install a new piston ring on the rack. Place a seal protector over the rack teeth. Next, slide the inner rack seal over the rack teeth and bottom the seal against the piston. Remove the protector.

E. Slide the rack and seal into the housing. Seat the inner seal by tapping the end of the rack with a soft-faced mallet.

F. Place seal protector over the rack and install the bulkhead, the seal, and the retaining ring. Then remove the seal protector.

G. Install new seals on the control valve.

H. Center the rack in the housing and install the pinion and control valve assembly. Align the pinion shaft with the mark made during disassembly.

I. Install the stub shaft bearing, the seal, the dust seal and retaining ring.

J. Hold the pinion in position; install and torque the lock nut.

K. Install the rack bearing. Next install the spring and adjuster. Turn the adjuster clockwise until it bottoms; then back off the adjuster a specified amount. Hold the adjuster position and tighten the lock nut to the specified torque.

L. Install tie rods as previously outlined.

1. To prevent gear damage, be sure to prevent the rack from turning while tightening the tie rods.

2. Align the breather tube with the marks made during disassembly. Reinstall the tube.

JS1-L2-UV

MODULE: STEERING AND SUSPENSION SYSTEMS

REMOVING AND INSTALLING A POWER RACK AND PINION STEERING GEAR

Equipment:

Drain pan
Hand tools
Hoist
Torque wrench
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. When necessary, place the vehicle securely on safety stands or lift it with a hoist.

   (CAUTION: Always use proper equipment when lifting a vehicle.)

3. Using a service manual or other information source, locate a procedure for removing the power rack and pinion steering gear. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, remove the power rack and pinion steering gear.

   a. Clean all dirt from around fluid line connections at the steering gear. Doing so will prevent the power steering system from becoming contaminated when the lines are disconnected.

   b. Remove both fluid lines from the steering gear. Plug both the fluid lines and the steering gear ports.

   c. Inspect the gear assembly for fluid leaks and housing damage. Record observations.

d. Inspect the condition of rubber mounting bushings and grommets. Inspect the condition of the flexible coupling. Replace any defective parts. Record observations.

e. Inspect the pressure and return hoses. Record observations.

4. Using a service manual or other information source, locate a procedure for installing the power rack and pinion steering gear. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, install the power rack and pinion steering gear.

a. Be sure all defective parts are replaced as directed by the instructor.

b. Fill the steering reservoir with the factory-recommended fluid and bleed the system.

c. After lowering the vehicle, check and adjust toe-in. See the instructor for this procedure.

d. Check operation of the power steering system. Record observations.

JS2-L2-UV

MODULE: STEERING AND SUSPENSION SYSTEMS

DISASSEMBLING, CLEANING, AND INSPECTING A POWER RACK AND PINION STEERING GEAR

Equipment:

Hand tools
Drain pan
Vise or holding fixture
Specialty tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Remove the steering gear from the vehicle, if required. For this procedure, refer to JS1-L2-UV.

3. Using a service manual or other information source, locate a procedure for disassembling the power rack and pinion steering gear. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, disassemble the power rack and pinion steering gear.

   a. Plug fluid ports and thoroughly clean the exterior of the steering gear with a safety solvent.

      (**NOTE:** Some steering gears contain components that cannot be serviced. Manufacturers of these gears recommend that the gears not be disassembled. Closely follow the manufacturer's disassembly procedures and recommendations for the gear to be serviced.)

4. Using a service manual or other information source, locate a procedure for cleaning and inspecting the steering linkage components. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, clean and inspect the steering linkage components.

a. Thoroughly clean all parts in clean safety solvent and blow them dry.

b. Use the following checklist to identify any defective components found during the inspection. Add components to the list if necessary.

Gear housing	OK_____	NOT OK_____
Rack	OK_____	NOT OK_____
Pinion and control	OK_____	NOT OK_____
Valve assembly	OK_____	NOT OK_____
Pinion bearings	OK_____	NOT OK_____
Rack bearing	OK_____	NOT OK_____
Bulkhead	OK_____	NOT OK_____
Seals	OK_____	NOT OK_____
Rack bushings	OK_____	NOT OK_____

Suggest the proper procedures for correcting any problems identified in the above checklist.

JS3-L2-UV

MODULE: STEERING AND SUSPENSION SYSTEMS

REASSEMBLING AND ADJUSTING A POWER RACK AND PINION STEERING GEAR

Equipment:

Hand tools
Torque wrench
Vise or holding fixture
Specialty tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for reassembling the steering gear. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, reassemble the steering gear.

   a. Be sure that all damaged or missing parts discovered when performing JS2-L2-UV have been replaced as directed by the instructor.

   b. Lightly coat all components with the appropriate power steering fluid during assembly.

3. Using a service manual or other information source, locate a procedure for adjusting the steering gear. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, adjust the steering gear. Record observations.

4. Turn the pinion through several complete left-to-right turns. Note any binding or roughness. Record observations.

5. Reinstall the rack and pinion steering gear on the vehicle if required. For this procedure, refer to JS1-L2-UV.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VI: POWER STEERING PUMP SERVICE AND DIAGNOSIS

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose and service power steering pumps and check power steering system pressure. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the equipment needed for testing power steering systems (Competency R8, Unit VI Test).

II. Identify the procedures for hooking up the power steering testing equipment (Competency R8, Unit VI Test).

III. Identify the procedures for checking power steering system pressure (Competency R8, Unit VI Test).

IV. Demonstrate the ability to:

   a. Test power steering system pressure (Competency R8, JS1-L1-UVI).

Lesson 2.

I. Identify the procedures for removing and replacing a power steering pump (Competency R8, Unit VI Test).

II. Identify the procedures for servicing power steering hoses (Competency R8, Unit VI Test).

III. Identify the procedures for servicing a power steering pump (Competency R8, Unit VI Test).

IV. Demonstrate the ability to:

   a. Remove and install a power steering pump (Competency R8, JS1-L2-UVI).

   b. Remove and replace a power steering pressure hose (Competency R8, JS2-L2-UVI).

   c. Service a power steering pump (Competency R8, JS3-L2-UVI).

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VI: POWER STEERING PUMP SERVICE AND DIAGNOSIS

CONTENTS OF THIS UNIT

A. Objective sheet

B. Lesson plans

1. Lesson 1: PRESSURE TESTING POWER STEERING SYSTEMS

   a. Information outline

   b. Job sheet

      JS1-L1-UVI: Testing Power Steering System Pressure

2. Lesson 2: POWER STEERING PUMP AND HOSE SERVICE AND REPLACEMENT

   a. Information outline

   b. Job sheets

      JS1-L2-UVI: Removing and Installing a Power Steering Pump

      JS2-L2-UVI: Removing and Replacing a Power Steering Pressure Hose

      JS3-L2-UVI: Servicing a Power Steering Pump

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VI: POWER STEERING PUMP SERVICE AND DIAGNOSIS

LESSON 1: PRESSURE TESTING POWER STEERING SYSTEMS

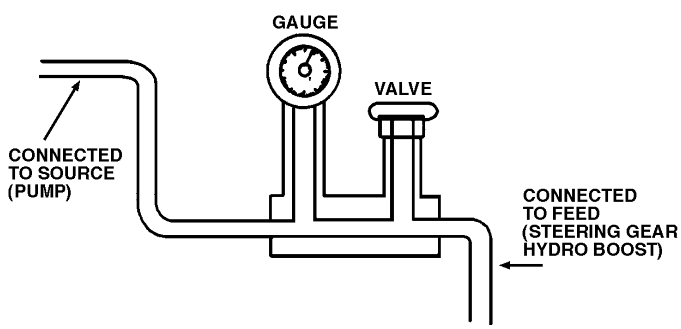
I. Equipment needed for testing power steering systems

A. Hydraulic pressure gauge capable of reading from 0 to 2000 pounds per square inch of pressure

B. Hydraulic hose with adapters to fit various vehicles

C. Shutoff valve to control flow of power steering fluid

(**NOTE:** Depending on the equipment manufacturer, the gauge, hoses, and valves listed above can be thought of as either individual components or as components that make up a single tester.)



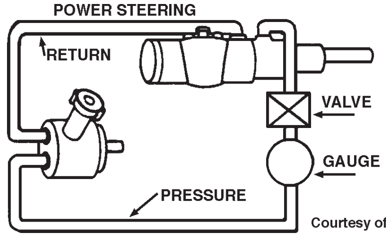
II. Hooking up power steering testing equipment

A. Procedure for hooking up test equipment to power steering systems

(**NOTE:** The procedure below applies to vehicles that do not use a hydralic brake booster.)

1. Clean dirt from around the pressure line fitting at the power steering pump.

2. Place the drain pan under the power steering pump and disconnect pressure outlet line.



Courtesy of Moog Automitive, Inc.

3. Remove the pressure hose from the power steering pump.

4. Using the appropriate adapters, connect the tester hose to the pump outlet.

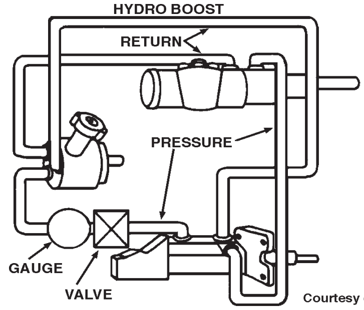
5. Using the proper adapters, connect the vehicle pressure hose (previously removed from the pump) to the outlet side of the tester shutoff valve.

   (CAUTION: Never use hoses or adapters that are not suitable for the high pressure encounter in the power steering systems. If a hose were to burst or a fitting were to come loose, bystanders could be severely burned by hot power steering oil.)

6. Open shutoff valve completely.

7. Add fluid and bleed air from the system, using the procedures outlined in Unit II of this module.

B. On vehicles with hydraulic power brakes, the power steering system provides pressure to both the power steering and the hydraulic brake booster. Procedures for hooking up test equipment to these systems are the same as those for standard power steering systems. Power steering systems that incorporate power brake boosters do, however, require different air bleeding procedures. These procedures are outlined below.



Courtesy of Moog Automotive, Inc.

1. Adjust fluid level in the same manner as for a standard power steering system.

2. With the engine running, apply the brakes until all air is expelled from the hydro-boost valve.

3. Stop the engine and add fluid if necessary. Restart the engine.

4. Turn the steering wheel from side to side several times.

(**NOTE:** Avoid turning the wheel all the way to the stops.)

5. Once again stop the engine and add fluid if necessary. Restart the engine.

6. Depress the brake pedal several times while turning the steering wheel from side to side.

7. Once again stop the engine and pump the brake pedal four to five times. Add fluid if required and restart engine.

8. Repeat the above steps until fluid is at the full level.

III. Checking power steering system pressure

(**NOTE:** Perform the test procedures outlined below with the power steering system test equipment connected and the engine running at an idle.)

A. Check pump flow pressure against manufacturer's recommendations. If pressure is in excess of 200 psi, check hoses for restrictions in the steering gear poppet valve.

B. Procedure for checking pump relief pressure (all makes of vehicles)

1. Completely close test valve and then open it. Perform this procedure three times. Record highest pressure noted each time the valve is opened and closed.

   (CAUTION: **Do not hold the valve closed for more than five seconds; doing so could damage the pump.)**

2. If the highest pressures noted during each of the three readings are within manufacturer's specifications and if the range of each reading is within 50 psi, the pump is functioning normally.

3. If the flow control valve is sticking, the pressure recorded during the first test will be high; the pressure recorded during a second test, however, will not fall within 50 psi of the reading from the first test. Repair or replace the valve as necessary.
4. If the pressures recorded are constant but below specifications, replace the flow control valve. If the pressures are still low, replace the pump.

C. Procedures for determining problems in the steering gear (integral), power cylinder and control valve (linkage type), and hydro-boost valve

1. If pump performance is within specifications when the test valve is open, turn the steering wheel to both the left and right stops and record the highest pressures. Compare these readings with maximum pump output.

2. If pump output can be repeated at either side of the stops, the entire system is satisfactory.

3. If pump output cannot be repeated, the steering gear, power assist cylinder, and control valve or hydro-boost valve are leaking internally.

4. Disconnect the pump pressure hose attached to the hydro-boost valve; also disconnect the pressure hose that connects the hydro-boost valve to the power steering gear.

   (**NOTE:** While the engine is off, pump the brake pedal several times to be sure that all pressure is discharged from the accumulator prior to disconnecting the hoses from the booster.)

5. Connect the two hoses so that the hydro-boost unit is bypassed.

   (CAUTION: **The vehicle will not have power-assisted brakes while the hydro-boost unit is bypassed.)**

6. Fill reservoir with the specified fluid and bleed system.

7. Turn the steering wheel to both the left and right stops and record the highest pressures. Compare these readings with maximum pump output. If the pressure reading equals pump output, steering gear is satisfactory and hydro-boost unit is faulty. If the pressure reading cannot equal pump output, steering gear is faulty and hydro-boost unit is satisfactory.

JS1-L1-UVI

MODULE: STEERING AND SUSPENSION SYSTEMS

TESTING POWER STEERING SYSTEM PRESSURE

Equipment:

Adapter hose and fittings
Drain pan
Hand tools
0-2000 psi pressure gauge
Shutoff valve
Safety valve
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for drawing a diagram which shows the way in which a pressure tester will be connected to the vehicle. The procedure must also tell all pressure specifications and which type of power steering fluid the vehicle needs. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, draw the diagram.

3. Following the diagram attach a pressure gauge and shutoff valve to the outlet side of the pump. Open the shutoff valve completely.

   (**NOTE:** Be sure to clean around the fittings before removing them. Doing so will prevent fluid contamination.)

4. Fill the pump reservoir with the correct fluid and bleed the system. See the text of this lesson for bleeding procedures.

5. With the tester valve still open, operate the engine at idle speed and read the gauge. The reading indicates the pump flow pressure. The reading should be within the specifications determined in item 2 of this job sheet. Record the pressure below.

   _______ psi

6. Close the test valve completely and then reopen it three times. Record the pressure each time the test valve is opened and closed.

   (CAUTION: Do not hold the valve closed for more than five seconds. Doing so could damage the pump.)

   1. _______ psi

   2. _______ psi

   3. _______ psi

   (**NOTE:** All three readings should be within 50 psi of each other and within manufacturer's specifications for pump relief pressure. See item 2 of this job sheet for specifications.)

7. Turn the steering wheel to the left and right stops and record the highest pressure.

   Left stop __________ psi

   Right stop __________ psi

   (**NOTE:** The pressure recorded at both steering stops should meet the pump output pressure.)

   (**NOTE:** If the vehicle is equipped with hydro-boost brakes and does not pass the test under item 6 above, the hydro-boost unit will have to be bypassed to isolate the cause of the problem.)

8. Disconnect the pressure test equipment from the vehicle.

9. Fill the power steering reservoir with the correct fluid and bleed the system.

10. Using the results of the above tests, describe the condition of the power steering system below. If any problems were discovered during the test, suggest appropriate repair procedures.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VI: POWER STEERING PUMP SERVICE AND DIAGNOSIS

LESSON 2: POWER STEERING PUMP AND HOSE SERVICE AND REPLACEMENT

I. Removing and replacing a power steering pump

  A. Procedure for removing a power steering pump

    1. Loosen adjustment brackets and remove the belt from the power steering pump pulley.

    2. Disconnect the pressure hoses and return fluid hoses.

      a. Clean dirt from around hose fittings before removing the hoses. Doing so will help to prevent contamination of the system.

      b. Place a drain pan under the vehicle to catch the fluid.

      c. After the lines are disconnected, plug the pressure and return lines and the pump ports.

    3. Remove the bolts attaching the pump to the engine.

      a. Depending on the application, one or more of the mounting brackets may be removed with the pump.

      b. After the bolts are removed, remove the pump from the vehicle.

  B. Procedure for inspecting a power steering pump

    1. Remove the dipstick and drain the fluid from the reservoir. If the pump has a separate reservoir, the fluid will not have to be drained.

    2. Replace the dipstick. While the fluid ports are still plugged, clean the exterior of the pump with safety solvent and inspect the pump pulley, reservoir, mounting brackets, and drive belts as outlined below.

    3. Inspect pump pulley.

      a. Visually inspect the pulley for dents or cracks.

      b. Turn the pulley and watch for excessive wobble.

      c. If any defects are found, replace the pulley.

(**NOTE:** Replacement pumps generally are not equipped with a pulley. The old pulley must be removed and installed on the new pump. The old pulley should, therefore, be inspected carefully.)

4. Inspect the reservoir.

    a. Inspect the reservoir for cracks or large dents.

    b. If the reservoir is defective, replace it.

    (**NOTE:** Replacement pumps may or may not be equipped with a reservoir. Before installing an old reservoir on a new pump, make sure the reservoir is in good condition.)

5. Inspect mounting brackets.

    a. Inspect for bent or cracked mounting brackets.

    b. If the mounting bracket incorporates a screw-type belt adjuster, make sure the adjuster operates smoothly.

    c. Replace any broken, cracked, or bent mountings.

6. Inspect drive belt.

    a. Inspect the belt for glazing, fraying, or cracking.

    b. If the belt is defective, replace it.

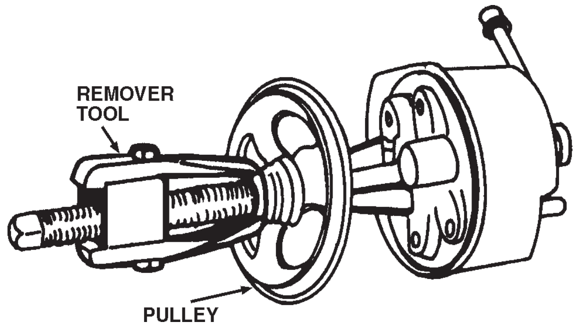
C. Removing and installing a pulley

1. Procedure for removing a pulley

    a. Install a suitable pulley removal tool on the pulley hub.

    b. Place the removal tool in a bench vise with the pump pointing upward.

    c. Hold the pump and rotate the removal tool nut counterclockwise to remove the pulley.
    (**NOTE:** Do not apply inward or outward pressure on the pulley shaft to remove or install the pulley. Doing so will cause internal pump damage.)



2. Procedure for installing a pulley

   a. Place the pulley against the pump shaft. Screw the installation tool into the threaded hole in the pump shaft.

   b. Place the end of the tool in the vise with the pump extending upward.

   c. Hold the pump and turn the tool nut to install the pulley on the pump shaft.

   d. The pulley is usually installed flush with the end of the pump shaft.

D. Removing and installing the reservoir

1. Procedure for removing the reservoir

   a. Support the pump housing securely in a vise or holding fixture.

      (**NOTE:** Do not clamp the shaft in a vise.)

   b. Remove the outlet fitting and o-ring.

   c. Remove any other retaining bolts.

   d. Using a wood block and a hammer (or a soft-faced hammer), tap around the flange of the reservoir to release it from the pump.

      (**NOTE:** Never tap around the flange with a steel hammer or pry directly on the reservoir.)

   e. Remove and discard the pump to reservoir o-ring.

   f. Thoroughly clean the reservoir in safety solvent and blow dry.

      (**NOTE:** To remove fiberglass-reinforced nylon reservoirs, grasp the reservoirs on both sides and twist them back and forth. Do not hammer on fiberglass-reinforced reservoirs with a wood block.)

2. Procedure for installing a reservoir

a. Install a new reservoir o-ring seal and outlet fitting gasket on the pump housing.

b. Coat the inside edge of the reservoir and the o-ring with petroleum jelly.

c. Place the reservoir over the pump housing and carefully align all holes.

d. Tap the reservoir into place with a hammer and a block of wood.

e. Install all retainers and tighten them to specified torque.

E. Procedure for pump installation

1. If any mounting brackets were removed along with the pump, install them on the pump housing.

2. Install the pump on the vehicle.

   a. Tighten all mounting fasteners to specified torque.

   b. Leave adjuster bolts loose at this time.

3. Attach pressure and return lines and tighten to specified torque.

4. Place the drive belt over the pulley.

F. Procedure for adjusting belts

1. A belt tension gauge tool is needed to adjust the belt accurately.

2. Place the tension gauge on the drive belt, midway between the pulleys. Note the tension reading on the gauge. Compare this reading to the specification in the service manual and adjust the belt accordingly.

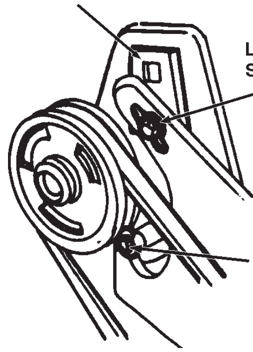
3. Adjust the belt by sliding the pump on the slotted holes in the bracket. Some of the more popular methods of sliding the pump are listed below.

   a. Some vehicles have a screw-type adjuster that moves the pump inward or outward in the slotted holes.

   b. Other vehicles require that the pump be pried inward or outward before it can be moved in or out of the slotted holes.

   c. In still other vehicles, the pump bracket has a hole into which a tool may be inserted for pump removal.

   (CAUTION: Never pry on the reservoir. Doing so may dent or crack the reservoir.)



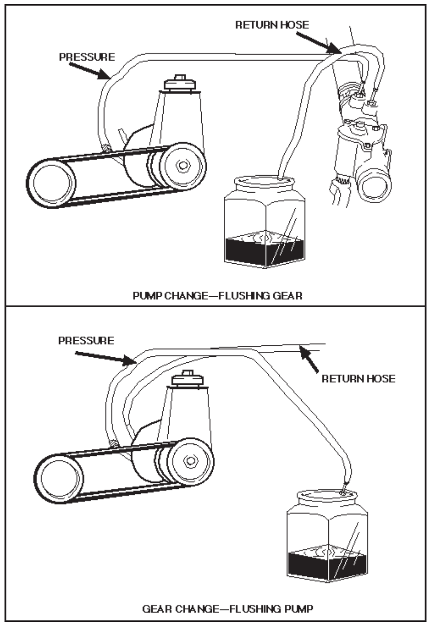
II. Servicing power steering hoses

A. Hoses should be inspected for the following problems: dampness and leakage at crimp joints, abnormal swelling, abrasions, or cracks. Also note if hoses have a soft or spongy feel, which is a sign of internal deterioration.

(**NOTE**: Normal component wear will introduce contaminants into the power steering system. These contaminants circulate throughout the system, acting as cutting agents that will eventually cause hydraulic seal failure. For this reason, whenever a power steering system is serviced, the system must always be flushed.)

B. Procedure for replacing a hose

1. Thoroughly clean areas around hose connections to help prevent contamination of the system.
2. Carefully check hose routing before removal.
3. Tighten all hose fittings to factory-specified torque.
4. Always replace any o-rings.
5. Fill and bleed the power steering system.
6. Inspect system for leakage.
7. Flush power system pump and gear.



III. Servicing a power steering pump

A. Procedure for disassembling a power steering pump

1. Clean pump and remove pulley and reservoir as outlined earlier in this lesson.

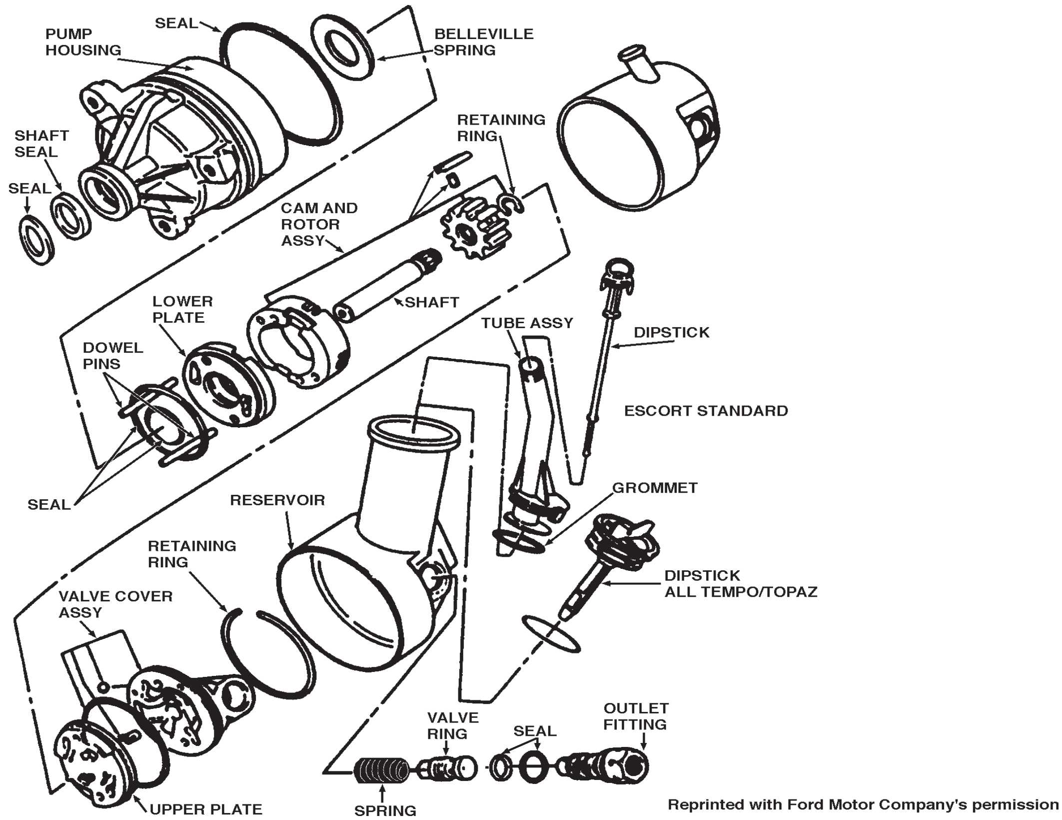
2. Remove the flow control valve.

3. Remove end cover retainer. Remove end cover and spring from the housing.

4. Remove the pressure plate, rotor, cam ring, and thrust plate from the housing.

5. Remove and discard end cover o-rings and pressure plate o-rings.

6. Pry out shaft seal and discard it.



B. Procedure for cleaning and inspecting a power steering pump

1. Clean all parts in safety solvent and blow them dry.

2. Procedure for inspecting a power steering pump

   a. Inspect shaft and bushings for wear or damage.

   b. Inspect the rotor assembly and cam ring, the thrust and pressure plates, and all other internal parts for wear, scoring, or other damage.

   c. Replace any worn or damaged parts. Always install new seals and gaskets.

C. Procedures for reassembling a power steering pump

1. Assemble the power steering pump in reverse order of disassembly.

2. Coat all parts with power steering fluid during reassembly.

3. To prevent cutting o-rings during assembly, coat o-rings and mating surfaces with petroleum jelly.

4. Install a new shaft seal using a suitable driver.

5. Tighten all fasteners to specified torque.

JS1-L2-UVI

MODULE: STEERING AND SUSPENSION SYSTEMS

REMOVING AND INSTALLING A POWER STEERING PUMP

Equipment:

Hand tools
Drain pan
Belt tension gauge
Torque wrench
Specialty tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for removing the power steering pump. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ **Instructor Approved**

   Following the procedure, remove the power steering pump. Record observations.

   a. Before removing the pump, be sure to clean around the hose fittings to prevent contamination of the system.

   b. After removing the pump, be sure to plug the hose fittings on the pump fluid ports.

3. Using a service manual or other information source, locate a procedure for cleaning and inspecting the power steering pump and mountings. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, clean and inspect the power steering pump and mountings. Use the following checklist to indicate problems with the pump.

Pulley	OK_____	NOT OK_____
Reservoir	OK_____	NOT OK_____
Mountings	OK_____	NOT OK_____
Hoses	OK_____	NOT OK_____
Drive belt	OK_____	NOT OK_____

4. If necessary, change the pulley that drives the new pump. Use the proper tools.

5. Following the procedure outlined below, replace the reservoir, if necessary.

   a. Support the pump housing in a vise or holding fixture while the reservoir is being changed.

   b. Remove the reservoir by tapping it with a block of wood and a hammer or by grasping and twisting it back and forth.

   c. Clean the reservoir thoroughly and install a new pump housing to the reservoir o-ring.

   d. Coat the o-ring with petroleum jelly and install the reservoir on the new pump.

   (**NOTE:** Do not hammer on reservoirs made of fiberglass-reinforced nylon.)

6. Using a service manual or other information source, locate a procedure for installing the power steering pump and adjusting drive belt tension. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the procedure, install the power steering pump.

   a. Adjust the power steering drive belt to the specified tension.

   b. Tighten all fasteners to the specified torque.

   c. Fill the power steering reservoir with the correct fluid and bleed the system.

   d. Inspect for and correct any leaks.

JS2-L2-UVI

MODULE: STEERING AND SUSPENSION SYSTEMS

REMOVING AND REPLACING A POWER STEERING PRESSURE HOSE

Equipment:

Hand tools
Torque wrench
Hoist
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. If necessary, place the vehicle securely on safety stands or lift it with a hoist.

3. Using a service manual or other information source, locate a procedure for removing the power steering pressure hose. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, remove the power steering hose. Record observations.

   a. Thoroughly clean the area around the hose fittings before removing the hose; doing so will prevent the fluid from becoming contaminated.

   b. To make reassembly easier, note the manner in which the hose is routed.

4. Using a service manual or other information source, locate a procedure for installing a power steering pressure hose. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, install the power steering hose. Record observations.

a. Tighten fittings to specified torque.

b. Fill reservoir with specified fluid and bleed system.

c. Check for and repair any leaks.

d. Inspect the installation carefully to make sure the hose is not routed against a pulley, a hot exhaust manifold, or any other items which could damage the hose.

JS3-L2-UVI

MODULE: STEERING AND SUSPENSION SYSTEMS

SERVICING A POWER STEERING PUMP

Equipment:

Hand tools
Torque wrench
Specialty tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. If required, remove the pump from the vehicle. Refer to JS1-L2-UVI for this procedure.

3. Using a service manual or other information source, locate a procedure for disassembling the power steering pump. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, disassemble the power steering pump. Record observations.

4. Thoroughly clean all the steering pump components in safety solvent and blow them dry. Inspect the components. Use the chart below to indicate any problems with the components.

Housing	OK_____	NOT OK_____
Rotor	OK_____	NOT OK_____
Shaft	OK_____	NOT OK_____
Reservoir	OK_____	NOT OK_____
Pulley	OK_____	NOT OK_____
Pressure plate	OK_____	NOT OK_____
Thrust plate	OK_____	NOT OK_____
Vanes	OK_____	NOT OK_____
Cam ring	OK_____	NOT OK_____

Suggest steps of procedure for any item marked "NOT OK".

5. Using a service manual or other information source, locate a procedure for resassembling the power steering pump. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, resassemble the power steering pump. Record observations.

a. Be sure that all damaged or defective pump components have been replaced as directed by the instructor.

b. Tighten all fasteners to the specified torque.

(**NOTE:** Lightly coat all components with the appropriate power steering fluid during assembly.)

c. After assembly, manually rotate shaft and check pump for binding. Shaft should rotate freely. Some manufacturers give a turning torque specification for shaft rotation.

6. Reinstall the power steering pump on the vehicle, if required. For this procedure, refer to JS1-L2-UVI.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VII: STEERING COLUMN INSPECTION AND REPAIR

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose and repair steering columns. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the function of the energy-absorbing steering column (Competency R6, Unit VII Test).

II. Identify the four principal components of an energy-absorbing steering column (Competency R6, Unit VII Test).

Lesson 2.

I. Identify the procedures for diagnosing steering column problems (Competency R6, Unit VII Test).

II. Identify the procedures for removing and reinstalling a steering column (Competency R6, Unit VII Test).

III. Identify the procedures for servicing a steering column (Competency R6, Unit VII Test).

IV. Demonstrate the ability to:

a. Diagnose steering column problems and remove and install an energy-absorbing steering column (Competency R6, JS1-L2-UVII).

b. Disassemble, inspect, and reassemble an energy-absorbing steering column (Competency R6, JS2-L2-UVII).

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VII: STEERING COLUMN INSPECTION AND REPAIR

CONTENTS OF THIS UNIT

A. Objective sheet

B. Lesson plans

1. Lesson 1: OPERATION AND DESIGN OF THE ENERGY-ABSORBING STEERING COLUMN

    a. Information outline

2. Lesson 2: STEERING COLUMN SERVICE AND DIAGNOSIS

    a. Information outline

    b. Job sheets

    JS1-L2-UVII: Diagnosing Steering Column Problems and Removing and Installing an Energy-Absorbing Steering Column

    JS2-L2-UVII: Disassembling, Inspecting, and Reassembling an Energy-Absorbing Steering Column

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VII: STEERING COLUMN INSPECTION AND REPAIR

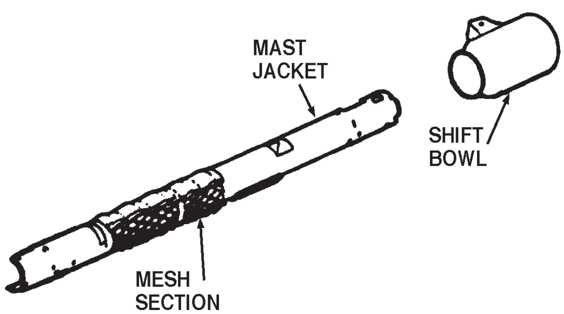
LESSON 1: OPERATION AND DESIGN OF THE ENERGY-ABSORBING STEERING COLUMN

I. All late-model vehicles use an energy-absorbing or collapsible steering column. During a frontal collision, the steering column compresses and reduces its tendency to move the steering wheel toward the rear of the vehicle. The column will also absorb the force of the driver's body being thrown against the steering wheel.

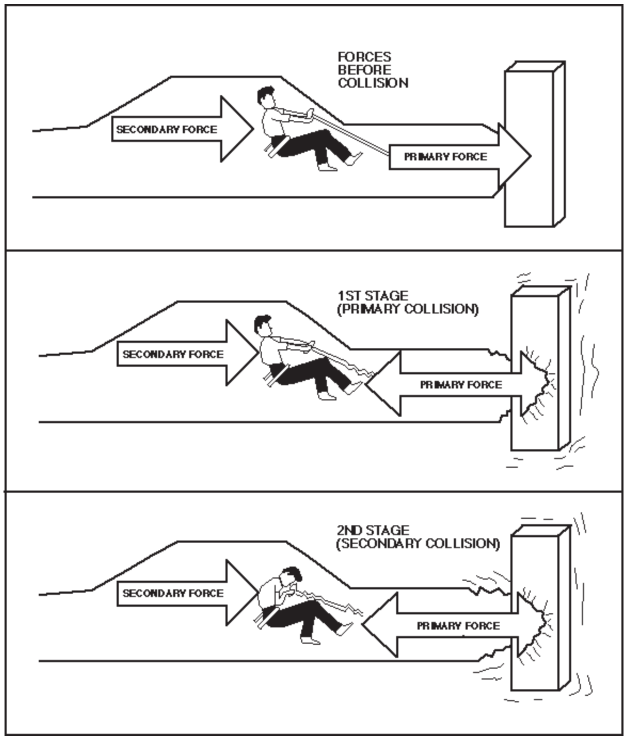
II. Four principal components of the energy-absorbing steering column

A. Column jacket (mast) is the outer shell or housing of the steering column. The jacket houses and supports the steering shaft and other internal components of the column.

1. Some column jackets have a slotted mesh section that rolls up at the lower end upon impact, thus shortening the column.

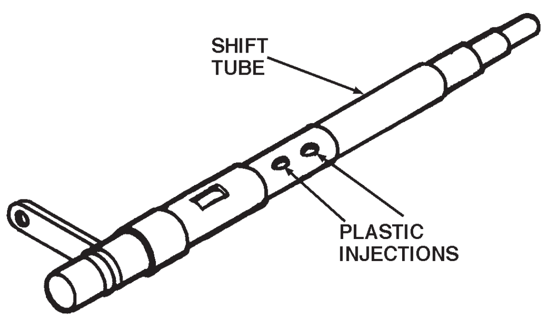


2. Other column jackets consist of two sections; steel balls imbedded in plastic are placed between these sections. Upon impact, the plastic is sheared and the two sections telescope together.

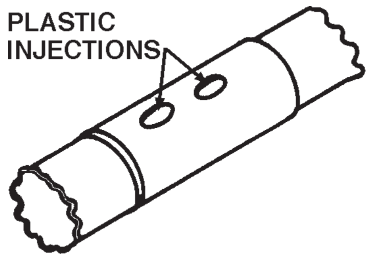


B. The gear shift tube is a hollow tube that fits over the steering shaft and connects the gear shift lever to the gear shift linkage at the base of the steering column. The tube is made of two pieces and held in position by injected plastic. Upon impact, the plastic is designed to shear, allowing the tube to telescope.

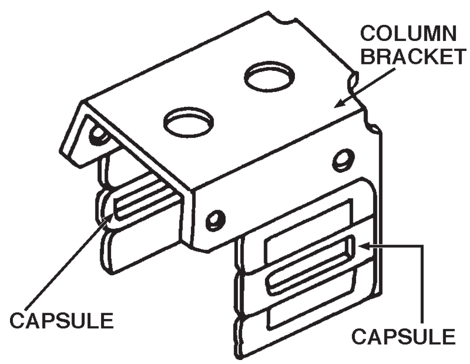
(**NOTE:** Not all vehicles use column-mounted gear shifters.)



C. The steering shaft connects the steering wheel to the steering gear. The steering shaft consists of a solid upper shaft inserted into a hollow lower shaft. The lower section of the upper shaft is double-flatted. The lower shaft is formed to fit over the double-flatted section of the upper shaft. (The double-flatted section allows the vehicle to be steered even though the column is completely telescoped.) Plastic is injected into the hollow lower shaft and into grooves in the solid shaft. Upon impact, the plastic shears, causing the shaft to collapse.



D. The column mounting bracket is located under the instrument panel. The brackets will allow the column to slide forward while blocking any movement of the column toward the rear of the vehicle (i.e. toward the driver). Each mounting bracket incorporates two breakaway capsules. The capsules allow the bracket to slip off the attaching points, permitting the steering column to compress in a forward direction.



MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VII: STEERING COLUMN INSPECTION AND REPAIR

LESSON 2: STEERING COLUMN SERVICE AND DIAGNOSIS

I. Diagnosing steering column problems

A. Steering column defects can cause problems throughout the steering system. A few of these steering system problems are listed below.

1. Bad steering shaft bearings can increase the amount of effort required to turn the steering wheel.

2. A rattle in the steering column might be caused by broken plastic in the collapsible steering shaft.

3. A broken shift tube can cause the transmission to operate improperly.

B. Steering columns can have many different problems. Many service manuals have a diagnosis chart to help the technician correctly diagnose the problem.

II. Removing and reinstalling a steering column

A. Procedure for removing a steering column

1. Disconnect the negative battery cable.

2. Remove clamp bolt from the flexible coupling at the lower end of the column shaft.

3. Disconnect the shift linkage from the shift tube at the lower end of the steering column.

4. Remove the steering wheel (only if the steering column is to be serviced after it is out of the car).

a. Remove horn pad assembly and disconnect horn wires.

b. Remove steering wheel nut retainer and attaching nut.

c. Using a suitable steering wheel puller, remove the steering wheel. (**NOTE:** Never remove a steering wheel by hitting the end of the steering shaft with a hammer; doing so may damage the energy-absorbing column.)

5. Remove the floor plate to the floor pan attaching screws.

6. Remove the trim cover from the lower instrument panel.

7. Remove the shift indicator needle or cable from the shift bowl.

8. Remove all wiring harness connections.

9. Remove the nuts from the brackets that support the column. These brackets are located under the instrument panel.

   a. Support the column while removing the nuts.

   b. Lower column and unplug wiring connectors.

      (**NOTE:** Note the positioning of any spacers used in the column mounting bolts.)

10. Carefully remove the steering column from the vehicle.

    (**NOTE:** Once removed from the car, the steering column is extremely susceptible to damage. Dropping the column on its end could collapse the steering shaft or loosen the plastic injections. Leaning on the column assembly could bend or deform the jacket. Such damage could impair the column's ability to collapse on impact. If the steering wheel must be removed, use a standard wheel puller. Never hammer on the end of the shaft; doing so could loosen the plastic injections, which maintain column rigidity.)

B. Procedure for installing the steering column

1. Carefully position the steering column from inside the car through the cowl.

2. Connect all wiring before raising the steering column.

3. Raise the steering column and install any spacers. Install the nuts loosely to support bracket bolts.

4. Install the flexible coupling clamp bolt and tighten to specified torque.

5. Inspect the flexible coupling alignment. If necessary, move the column to align it.

6. Install and torque the floor pan screws.

7. Tighten the instrument panel support bracket nuts to the specified torque.

8. Install the gear shift indicator needle or cable.

9. Install the trim cover on the lower instrument panel.

10. Install the steering wheel.

    a. Align the marks on the steering shaft and steering wheel hub and position the wheel on the shaft.

b. Install the wheel nut and tighten to specified torque.

c. Install the steering wheel nut retainer.

d. Connect the horn wires and install steering wheel pad.

11. Connect the negative battery cable.

(**NOTE:** Failing to tighten bolts to the specified torque or installing bolts that are too long could render an energy-absorbing steering column ineffective.)

III. Servicing a steering column

(**NOTE:** The following two procedures are very general in nature. Due to the large variety of steering column designs, it is impossible to list a service procedure for each one. Consult the appropriate service manual for the specific vehicle to be serviced.)

A. Procedure for disassembling the steering column

1. Remove the steering column from the vehicle as outlined above.

2. Remove the steering wheel.

3. Remove the steering wheel lock plate and turn the signal canceling cam.

4. Remove the turn signal switch.
5. Remove the ignition lock cylinder and key warning buzzer switch.

6. Remove the ignition switch, backup light switch, and dimmer switch.

7. Remove the wiper switch and steering column housing.

8. Remove the gear shift lever, lever bowl, and shift bowl shroud.

9. Remove the steering shaft and shift tube from mast jacket.

B. Procedure for inspecting steering column components

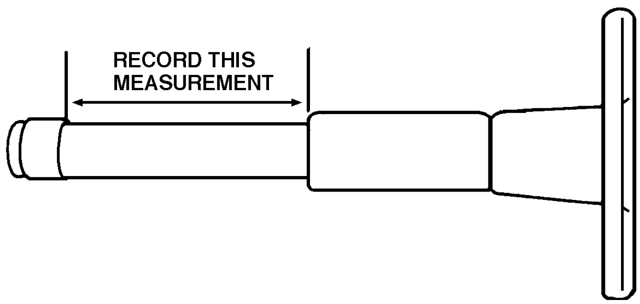
1. Make sure that the two-piece steering shaft is straight and that the plastic injections are secure.

2. Inspect the bearings for looseness or damage.

3. Inspect the shift tube and shift bowl for wear or breakage.

4. Inspect the tilt mechanism for wear or damage.

5. If the steering column has been impacted during an accident, the steering column and steering shaft should be carefully inspected for signs of collapsing. The steering column mounting bracket capsules should also be inspected for movement. The following diagram shows one manufacturer's procedure for determining if a column has been damaged in an accident.



C. Procedure for reassembling the steering column

1. To assemble the steering column, reverse the disassembly procedure.

2. Be sure to tighten all fasteners to specified torque.

3. Prior to assembly, lubricate bearings with multipurpose grease.

4. Adjust all switches according to the manufacturer's instructions.

D. Some steering column service procedures can be performed without removing the column from the vehicle. Some of these procedures are listed below.

1. Steering wheel removal and installation

2. Turn signal switch replacement

3. Ignition switch replacement

4. Gear shift lever replacement

JS1-L2-UVII

MODULE: STEERING AND SUSPENSION SYSTEMS

DIAGNOSING STEERING COLUMN PROBLEMS AND REMOVING AND INSTALLING AN ENERGY-ABSORBING STEERING COLUMN

Equipment:

Hand tools
Steering wheel puller
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Inspect the operation of the steering column. Answer the questions below. In the space below the questions, suggest procedures to correct any problems found during the inspection.

    a. Does the steering wheel lock correctly?

    Yes_____ No_____

    b. Does the ignition switch operate correctly?

    Yes_____ No_____

    c. Is the amount of effort required to turn the steering wheel appropriate? (If the vehicle has power steering, start the engine before performing this test.)

    Yes_____ No_____

d. Are there any unusual noises when the steering wheel is turned? (If the vehicle has power steering, start the engine before performing this test.)

Yes_____ No_____

e. Does the column shift lever operate correctly? (This question applies only to vehicles using column shifters.)

Yes_____ No_____

f. Does the tilt mechanism operate correctly? (This question applies only to vehicles equipped with a tilt mechanism.)

Yes_____ No_____

g. Does the column seem to be loose while the steering wheel is being turned?

Yes_____ No_____

3. Using a service manual or other information source, locate a procedure for removing the steering column. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, remove the steering column. Record observations.

4. Inspect the column assembly. Answer the questions below. In the space after the questions, suggest procedures to correct any problems found during the inspection.

   a. Does the flexible coupling exhibit signs of wear?

      Yes_____ No_____

   b. Do the column mountings exhibit signs of looseness or cracking?

      Yes_____ No_____

   c. Are there any loose grommets on the shift linkage?

      Yes_____ No_____

5. Using a service manual or other information source, locate a procedure for installing the steering column. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, install the steering column. Record observations.

   a. Make sure any spacers used on the mounting brackets are reinstalled in their proper locations.

   b. Tighten all fasteners to specified torque.

   c. Check the alignment of the flexible coupling.

6. After the steering column has been installed start the engine and inspect the column as outlined below. **Be sure to obtain the instructor's permission before making the checks.**

   a. Put the gear shift in all positions and watch for any problems in the column. Record observations.

   b. Watch for any problems in the column while turning the steering wheel through left and right turns. Record observations.

   c. Check operation of all electrical devices in the steering column. Record observations.

JS2-L2-UVII

MODULE: STEERING AND SUSPENSION SYSTEMS

DISASSEMBLING, INSPECTING, AND REASSEMBLING AN ENERGY-ABSORBING STEERING COLUMN

Equipment:

Hand tools
Specialty tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. If required, remove the steering column from the vehicle. Refer to JS1-L2-UVII for this procedure.

3. Using a service manual or other information source, locate a procedure for disassembling the steering column. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, disassemble the steering column. Record observations.

   (**NOTE:** Do not drop the steering column or hammer on the steering shaft; doing so could collapse the steering column or loosen the plastic injections.)

4. Inspect the steering column. Use the below checklist to indicate problems with steering column components.

Mast jacket	OK______	NOT OK_____
Steering shaft	OK______	NOT OK_____
Shift tube	OK______	NOT OK_____
Shift bowl	OK______	NOT OK_____
Steering shaft bearings	OK______	NOT OK_____
Wheel lock mechanism	OK______	NOT OK_____
Tilt mechanism	OK______	NOT OK______

Suggest repair procedures for any components marked "NOT OK."

5. Using a service manual or other information source, locate a procedure for assembling the steering column. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, assemble the steering column. Record observations.

a. Tighten all fasteners to specified torque.

b. Replace all defective or missing parts as directed by the instructor.

c. Adjust all switches as directed in the service manual.

6. Reinstall the steering column in the vehicle, if required. Refer to JS1-L2-UVII for this procedure.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VIII: FRONT SUSPENSION SYSTEM DESIGNS

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the components and operating principles of various types of front suspension systems. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions related to front suspension systems (Competencies S1-S6, Unit VIII Test).

II. Identify the basic components and design of a suspension system (Competencies S1-S6, Unit VIII Test).

Lesson 2.

I. Identify the characteristics of an SLA suspension (Competencies S1-S4, Unit VIII Test).

II. Identify the characteristics of a conventional MacPherson strut front suspension (Competencies S5 and S6, Unit VIII Test).

III. Identify the characteristics of a modified MacPherson strut suspension (Competencies S5 and S6, Unit VIII Test).

IV. Identify the characteristics of a straight axle front suspension (Competencies S1-S4, Unit VIII Test).

V. Identify the characteristics of a four-wheel-drive front axle suspension (Competencies S1-S4, Unit VIII Test).

VI. Identify the characteristics of a twin I-beam front suspension (Competencies S1-S4, Unit VIII Test).

Lesson 3.

I. Identify the characteristics of tapered wheel bearings (Competencies S1-S3, Unit VIII Test).

II. Identify the characteristics of double row ball or roller bearings (Competencies S1-S3, Unit VIII Test).

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VIII: FRONT SUSPENSION SYSTEM DESIGNS

CONTENTS OF THIS UNIT

A. Objective sheet

B. Lesson plans

1. Lesson 1: SUSPENSION SYSTEM PARTS

    a. Information outline

    b. Assignment sheet

    AS1-L1-UVIII: Suspension System Components

2. Lesson 2: TYPES OF FRONT SUSPENSION SYSTEMS

    a. Information outline

    b. Assignment sheet

    AS1-L2-UVIII: Types of Steering Systems

3. Lesson 3: THE DESIGN AND FUNCTION OF WHEEL BEARINGS

    a. Information outline

    b. Assignment sheet

    AS1-L3-UVIII: Wheel Bearings

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VIII: FRONT SUSPENSION SYSTEM DESIGNS

LESSON 1: SUSPENSION SYSTEM PARTS

I. Terms and definitions

A. **Aeration** — Air mixing with hydraulic fluid, causing the fluid to foam.

B. **Ball joint** — A suspension component that connects the control arm to the steering knuckle. The ball joint has the ability to tilt and rotate.

C. **Control arm** — A suspension component that links the vehicle wheels to the frame, thus allowing for suspension movement. Control arms are also referred to as "A" arms or wishbones because of their shape.

D. **Coil spring** — A suspension spring that consists of a spring steel bar wound into a coil.

E. **Independent suspension** — Front or rear suspension in which those wheels that are positioned opposite to each other on the axle move up and down independently of each other.

F. **Jounce** — The upward movement of the wheel and suspension system.

G. **Kingpin** — A hardened steel pin that passes through the outer end of the axle and the steering knuckle. The kingpin allows the steering knuckle to pivot on the axle. The kingpin is also referred to as a spindle bolt.

H. **Leaf spring** — The suspension spring is constructed of either a leaf or leaves made of flat spring steel.

I. **MacPherson strut** — The type of independent suspension in which a coil spring and shock absorber combination is used in place of an upper control arm.

J. **Rebound** — The downward movement of the wheel and suspension.

K. **Ride height** — The distance from a specific point on a vehicle to the road surface.

L. **Shock absorber** — A hydraulic device used to dampen spring movement (oscillations) in a suspension system. The shock absorber is also referred to as a shock.

M. **Spindle** — A component that extends outward from the steering knuckle. The spindle supports the wheel bearings and may or may not be integral with the knuckle.

N. **Sprung weight** — Vehicle weight that is supported by suspension springs.

O. **Stabilizer bar (also called sway or anti-sway bar)** — A suspension-control component used to minimize a vehicle's swaying and leaning during turns.

P. **Steering knuckle** — A component that is supported by and pivots on either upper and lower ball joints or a kingpin. The steering knuckle may be either integral with the spindle or bolted to it.

Q. **Straight axle** — A non-independent suspension axle. On a straight axle, movement of one wheel directly affects the opposite wheel.

R. **Strut rod** — A steel rod positioned between the frame and the lower control arm. The strut rod stabilizes the lower control arm.

S. **Torsion bar spring** — A suspension spring consisting of a round spring steel bar. One end of the torsion bar spring is attached to the lower control arm while the other end is attached to the vehicle's frame.

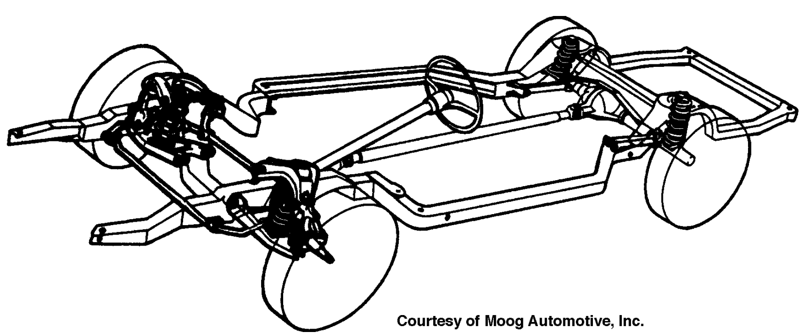
T. **Twin I-beam axle** — A suspension system that uses two axles shaped like an I-beam. One of the axles is connected to each wheel, thus allowing for independent suspension action.

U. **Unsprung weight** — Vehicle weight that is not supported by the suspension springs. Unsprung weight includes such items as wheels and tires.

II. Basic components and design of a suspension system

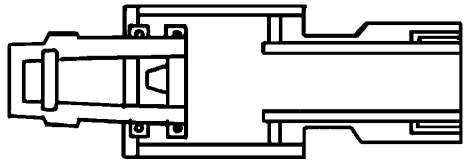
A. The vehicle's frame is the foundation upon which the entire vehicle is constructed. Most vehicles use either a conventional frame (also called a full frame) or a unibody frame.

1. A conventional frame (or full frame) is a sturdy steel frame to which the vehicle's body parts and all other major components are directly or indirectly attached. The frame provides the strength and rigidity required to keep the vehicle intact.



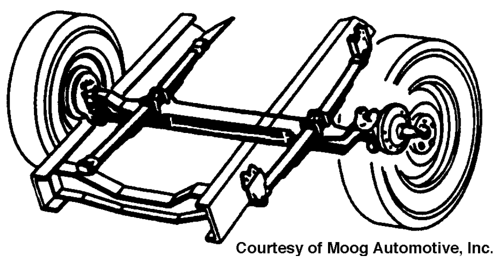
Courtesy of Moog Automotive, Inc.

2. A unibody frame has no separate frame structure. The vehicle body is designed so that the body parts themselves supply the strength and rigidity required to keep the vehicle intact.



B. Straight axle and independent front suspension suspensions

1. Most early passenger cars used a straight axle design. A major disadvantage of this design is that when one wheel is raised or lowered (as might occur when the vehicle hits a bump or pothole), the alignment of the opposite wheel is temporarily thrown off. On the other hand, the straight axle can support a great deal of weight and is, therefore, still used on large trucks and some four-wheel-drive vehicles.



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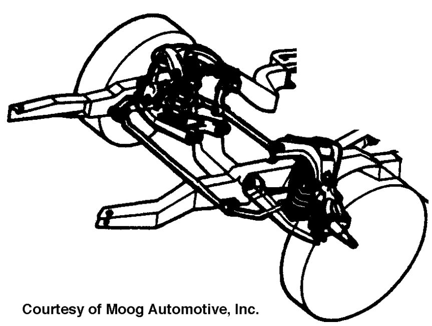
2. Independent front suspension allows each wheel to compensate for changes in the road surface without greatly affecting the other wheel at the same end of the vehicle. Independent front suspension, therefore, improves vehicle handling and increases tire life. Most passenger cars have used independent front suspension since the 1940's.



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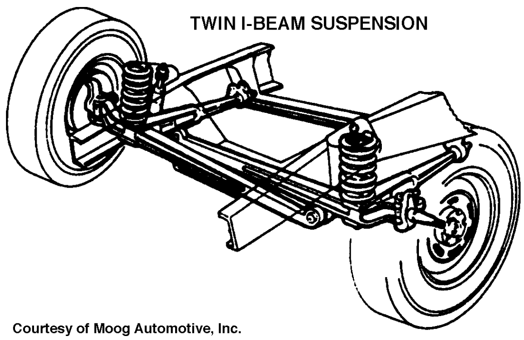
C. The springs in the suspension system absorb shocks and maintain the correct vehicle ride height. There are three basic types of suspension springs: coil springs, leaf springs, and torsion bar springs. A fourth type, called air springs, is used on a few vehicles; air springs will be discussed later.

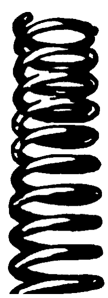
1. Coil springs

a. Coil springs are often used in today's passenger cars. The coil spring is made from a round spring steel bar stock, which is wound into the shape of a coil. The coil spring compresses to absorb a road shock and then rebounds to its original position, thus maintaining the proper ride height of the vehicle.



Courtesy of Moog Automotive, Inc.

b. On conventional front suspension systems, the spring is usually mounted between the frame and the lower control arm. Some front suspension designs, however, have the spring located between the spring tower and the upper control arm. Rubber insulators, positioned between the spring and its mounting surface, reduce suspension noise.



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2. Leaf springs

a. Leaf springs are used on solid axle rear suspensions and on front suspensions that use the straight axle design. These springs are commonly made from flat spring steel, which is shaped like an arch.

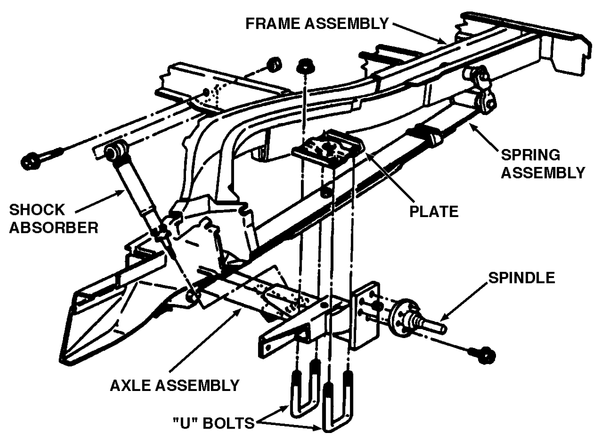
b. The main leaf of the leaf spring has a loop or eye machined into each end. A rubber bushing is inserted into each eye; by way of this bushing, the leaf is attached to the vehicle's frame. The rear of the spring is attached to the frame via a shackle assembly that permits the spring to lengthen or shorten according to the forces of acceleration and braking.

c. Additional leaves are added to the spring to achieve the desired stiffness and load-carrying capacity. (Each additional leaf is usually shorter than the one added previously.) The leaves are held in place by a tie bolt inserted through the center of the leaves and by rebound clips on the leaves' ends. The leaf spring is usually mounted at a right angle to the axle and is attached to the axle by U-bolts.

d. In multiple leaf springs, the leaves are usually separated by rubber, plastic, or zinc spacers called interleaves. The interleaves reduce any noise and wear that may result from the spring leaves working against each other.

e. A monoleaf spring consists of only one leaf. These springs are generally thick in the center and tapered down on each end. These leaf springs provide lighter vehicles with a smooth ride and greater load-carrying capability.

(**NOTE:** In order to achieve a lower vehicle weight some leaf springs use a single leaf spring made of fiberglass.)

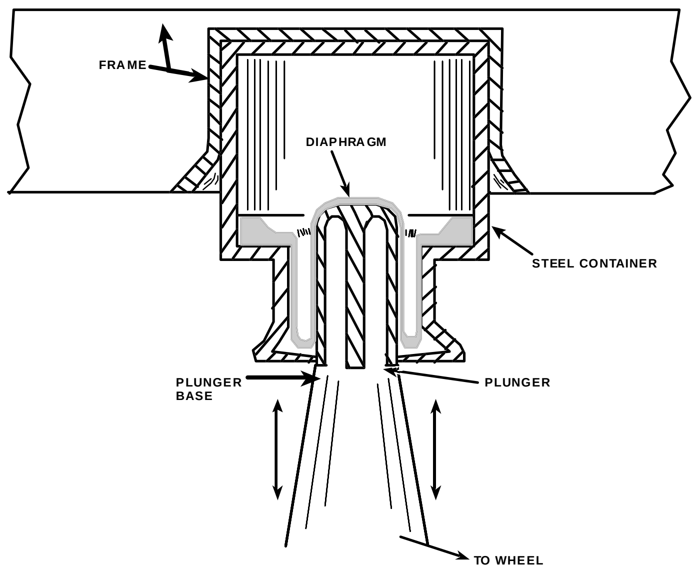


3. Torsion bar springs

a. A torsion bar spring is a long spring steel shaft. One end of the shaft is attached to the lower control arm while the other end is attached to the vehicle's frame.

b. When a wheel hits a bump in the road, the control arm moves, causing the torsion bar to twist and thus absorb the shock. After the shock is absorbed, the bar returns to its original position, thus returning the vehicle to its proper ride height.

(**NOTE:** Torsion bars can be adjusted to control the ride height of the vehicle.)



c. There are two basic designs of torsion bar springs: the straight type and the (cross) transverse type. Straight torsion bar springs are mounted to the frame behind the lower control arm and extend forward to the control arm. The (cross) transverse torsion bar springs are L-shaped and are mounted solidly to the frame on the front corner opposite to the wheel they serve. The springs run across the frame, parallel to the front frame crossmember, and then turn toward the rear of the vehicle and attach to the outer end of the lower crossmember in a rubber bushing.

D. Control arms

1. Upper control arms

a. The upper control arms are attached to the vehicle frame by way of bushings. The bushings allow the control arms to move up and down with the wheels. The control arm pivots on a steel shaft, which is bolted to the frame. (The control arm pivots in the shaft in either steel-clad rubber or threaded-steel bushings.)

b. The outer end of the control arm is attached to the steering knuckle via a ball joint. Attached to the control arms or vehicle frame are heavy rubber rebound bumpers. The rebound bumpers absorb the shock when suspension springs are compressed or extended to the point at which the control arms contact the frame.

c. On many vehicles, a provision for adjusting the wheel alignment is provided at the point where the upper control arm shaft connects to the vehicle.

2. Lower control arms

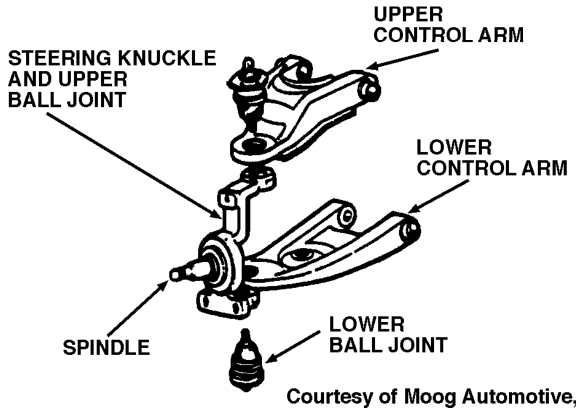
a. The double bushing lower control arm uses two bushings and two mounting points to connect the control arm to the frame. The double bushings and mounting points provide extra stability.

b. The single bushing lower control arm takes up less space than the double bushing arm but is more susceptible to movement. To control the extra movement, strut rods are usually added to the suspension system.

c. The lower control arm is usually bolted to the vehicle frame with a steel-clad rubber pivot bushing and bolt arrangement. The outer end of the lower control arm is attached to the steering knuckle by a ball joint.

d. The coil spring or torsion bar spring is usually attached to the lower control arm; however, some designs have the coil spring resting on the upper control arm.

e. In most modern independent front suspensions, the upper control arm is shorter than the lower control arm. This type of suspension is often referred to as short and long arm (SLA) suspension. SLA suspension allows for longer tire life than earlier systems in which both control arms are of the same length.

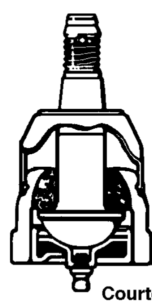


Courtesy of Moog Automotive, Inc.

E. Jounce rebound bumpers are solid rubber cushions that limit suspension travel and absorb the shock of suspension and frame contact. Jounce rebound bumpers are fastened to the control arms or the frame.

F. Ball joints

1. Ball joints are used to connect the steering knuckle to the outer end of the control arms. The joints allow the steering knuckle to turn between the control arms as the steering wheel is turned. The ball joints are attached to the steering knuckle via a tapered stud and nut arrangement or a straight stud with a notch and a pinch bolt.


Courtesy of Moog Automotive, Inc.

2. Ball joints are similar in design to the ball sockets found in tie rod ends and other steering linkage joints. Ball joints are heavier than ball sockets, however. There are two basic types of ball joints: load-carrying and nonload-carrying.

   a. Load-carrying joints support the weight of the vehicle. They are mounted on the outer control arm ends to which the coil springs are seated or to which the torsion bar springs are attached.

   b. Nonload-carrying joints contain a built-in preload. A spring maintains tension on the joint at all times and compensates for wear. The design of nonload-carrying joints helps to dampen vibration and road shock.

(**NOTE:** Nonload-carrying ball joints are also referred to as roller ball joints.)

G. Conventional shock absorbers

1. Conventional shock absorbers control or dampen suspension spring movement in both directions. Without shock absorbers, spring movement or oscillations (such as might result from hitting a bump) would continue until all energy was expelled from the spring. The result would be a very rough ride, which might result in loss of vehicle control.

2. Shock absorbers use hydraulic resistance to control spring oscillations. The shock absorber achieves this resistance by forcing fluid through metered, internal passages.

   (**NOTE:** Conventional shock absorbers do not control a vehicle's ride height. Ride height is controlled by the springs. Air adjustable shock absorbers do, however, affect vehicle ride height; these shock absorbers will be discussed in a later unit.)

3. Shock absorber construction

   a. The shock absorber consists of a piston and rod assembly, which operates within an inner steel tube (cylinder). The upper end of the cylinder is sealed by a piston rod seal; the lower end is sealed by a base compression valve assembly. The cylinder is completely filled with oil at all times. Surrounding the inner tube is an outer tube, which provides space for reserve fluid and overflow for the pressure tube.

   b. A rubber mounting bushing connects the piston rod to the vehicle frame. A lower mounting bushing connects the pressure and reservoir tubes to the suspension.

4. Operation of the shock absorber

   a. As the wheel moves up and down, the suspension spring compresses (jounce) and extends (rebound). This movement of the suspension spring, in turn, compresses or extends the shock absorber, thus pushing the shock absorber piston through a column of oil within the pressure tube.

   b. The piston contains metered orifices, which allow fluid to flow at a specific rate. Because fluid cannot be compressed, the size of the orifices determines the shock's effectiveness.

   c. In addition, when the shock is compressed, fluid is forced through the compression base valve into the reservoir tube.

   d. The faster the piston is pushed, the greater the pressure build-up below the piston and the greater the dampening force.

e. As the suspension rebounds, the piston is pulled up through the fluid above it. As the rebound speed increases, a blow-off disc opens to allow fluid to pass at a faster rate, thus making the vehicle ride more smoothly.

H. Gas-charged shock absorbers

1. During rapid jounce and rebound, the fluid in conventional shock absorbers tends to become aerated. Aeration causes the shock absorber to skip or become mushy. Like conventional shocks, gas-charged shocks also operate on the principle of hydraulic fluid displacement; gas-charged shocks, however, are not susceptible to aeration.

2. Design of the gas-charged shock

a. One common type of gas-charged shock uses a piston and oil chamber much like those found in conventional shocks; instead of a reserve tube, however, the gas-charged shocks incorporate a floating dividing piston that separates the oil chamber from the gas chamber.

b. The gas chamber contains nitrogen gas at a pressure of approximately 100 to 360 psi. As the main shock absorber piston moves up and down in the tube, the dividing piston and the gas chamber below it compensate for the difference in fluid volume, thus preventing the fluid from becoming aerated.

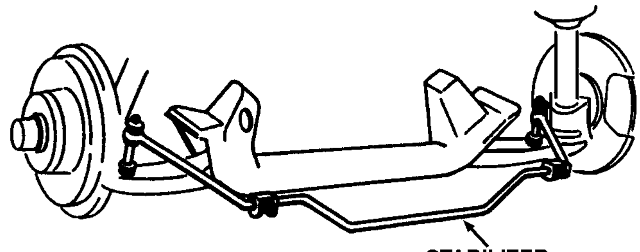
(**NOTE:** There are two classes of gas filled shocks: high pressure and low pressure. Most passenger vehicles use low pressure type gas shocks.)

I. A spring-assist shock absorber is a conventional shock absorber with a coil spring fitted around the outside of the shock. Spring-assist shocks allow the vehicle to carry greater loads.

J. The stabilizer bar (also called an anti-sway bar or sway bar)

1. The stabilizer bar can be added to a vehicle to improve the suspension's stability. A stabilizer bar consists of a "U-shaped" spring steel bar. Each end of the stabilizer bar is attached to a lower control arm via rubber mounts or links. The center portion of the "U" attaches to the vehicle's frame through rubber mounts.

2. When one of the vehicle's wheels is raised or lowered, the stabilizer bar begins to twist, applying force to the opposite control arm and thus keeping the vehicle in a more level position. The stabilizer bar thus reduces swaying and leaning of the vehicle's body and improves handling during cornering.



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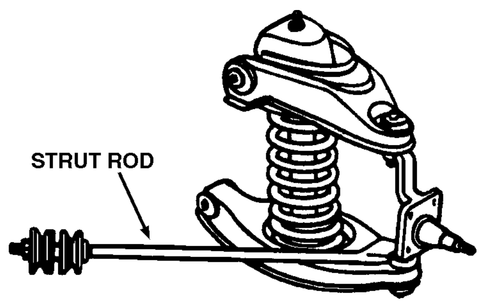
K. Strut rods are used to control movement of the lower control arm. Strut rods are more commonly found on suspension designs that use a single bushing lower control arm. The strut rod is bolted directly to the lower control arm and is attached to the vehicle's frame through rubber mounting bushings. Some designs have the sway bar double as strut rods.



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L. The wheel spindle assembly consists of the wheel spindle and the steering knuckle. The wheel spindle connects to the wheel through the wheel hub and bearings, which ride on the spindle. The steering knuckle is located in the inner portion of the spindle assembly and connects to the control arm through the ball joints. In some vehicles, spindle and steering knuckles consist of separate pieces bolted together; in other vehicles, spindle and steering knuckles are forged as a single unit.

AS1-L1-UVIII

MODULE: STEERING AND SUSPENSION SYSTEMS

SUSPENSION SYSTEM COMPONENTS

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. What is the major function of the suspension springs?

2. List the three types of suspension springs.

3. How are the control arms attached to the steering knuckles?

4. What suspension components are used to dampen spring oscillations?

5. What type of shock absorbers are not susceptible to fluid aeration?

6. What suspension component is used to prevent body sway?

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VIII: FRONT SUSPENSION SYSTEM DESIGNS

LESSON 2: TYPES OF FRONT SUSPENSION SYSTEMS

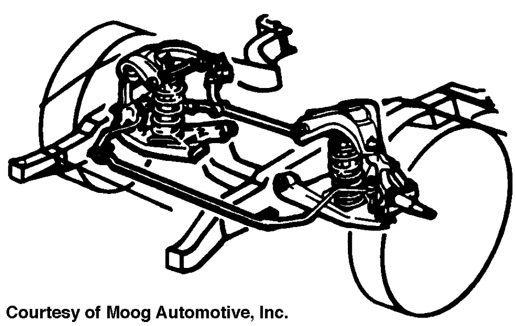
I. Conventional short and long arm suspension (referred to as SLA suspension) is an independent front suspension used on many American vehicles.

A. In SLA suspensions, an upper and lower control arm is located at each front wheel. The control arms are attached to the steering knuckle via upper and lower ball joints and to the frame via bushings.

B. The SLA suspension uses a coil or torsion bar spring to absorb shocks and maintain the correct ride height of the vehicle.

C. Most SLA designs have the coil springs resting on the lower control arm and are referred to as coil under suspensions. In these designs, the load-carrying ball joint is on the lower control arm. The ball joint on the upper control arm is the nonload-carrying ball joint. A shock absorber is mounted between the vehicle's frame and lower control arm.

(**NOTE:** The SLA suspension system normally uses a stabilizer bar.)



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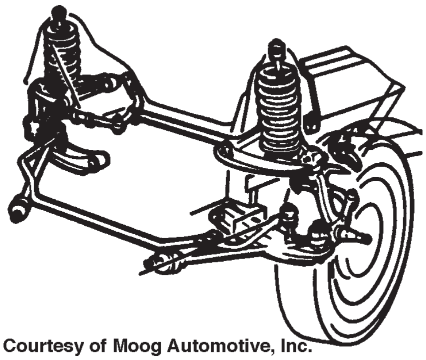
D. Some SLA designs have the coil spring resting on the upper control arm and are referred to as coil over suspensions. These designs require a spring tower, which is a special frame extension located above the coil spring. The upper end of the spring is seated on the spring tower. Also in these designs, the upper ball joint is the load-carrying joint and the lower ball joint is the nonload-carrying joint. A shock absorber is mounted between the spring tower and upper control arm. The lower control arm usually pivots on a single bushing, thus requiring a strut to stabilize the arm.

(**NOTE:** Stabilizer bars are also used on most of these systems.)



Courtesy of Moog Automotive, Inc.

II. Conventional MacPherson strut front suspension

A. Conventional MacPherson strut front suspension incorporates a shock absorber and a coil spring into a single unit. The MacPherson strut suspension is lighter and smaller than a conventional independent suspension and, therefore, is used quite frequently on today's vehicles. The unit is mounted between the steering knuckle and the vehicle's inner fender.

B. Design of the conventional MacPherson strut suspension

1. In some conventional MacPherson strut suspensions, the steering knuckle/spindle is permanently attached to the lower end of the strut assembly, while in others the lower end of the strut tube is bolted to the steering knuckle.

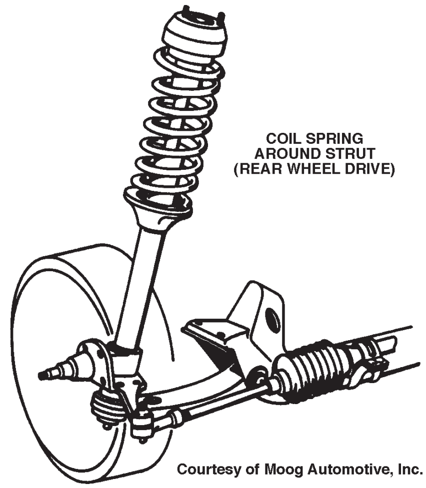
2. The upper end of the shock absorber (strut) piston rod attaches to a reinforced vehicle inner fender (the attachment is made via an upper mount, which is bolted to the fender). A rubber mounted bushing or bearing arrangement, located at the top mount, cushions the shock and allows the strut to turn with the wheel as it is steered.

3. A lower control arm is connected to the lower end of the steering knuckle via a ball joint. No upper control arm or upper ball joint is used with this design.

4. The shock absorber (dampener) fits inside the strut tube; the piston rod extends out of the top. Some MacPherson strut units allow a worn shock absorber (dampener) to be replaced. Other units require that the entire strut assembly be replaced if the shock absorber is worn.

5. The coil spring is serviced separately from the strut. The spring rests on a lower spring seat, which is welded to the strut tube. The upper end of the spring is retained by an upper spring seat, which either fits under or is integral with the upper strut mount. The spring is held in place on the strut assembly by a retaining nut on the piston shaft.

6. A stabilizer bar and strut rods are normally used with MacPherson struts.



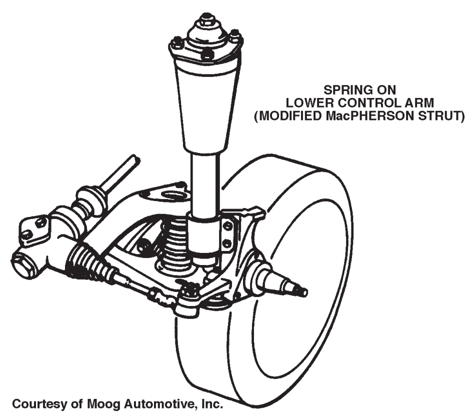
III. Modified MacPherson strut suspension

A. The modified MacPherson strut suspension system blends the SLA and the conventional MacPherson strut designs.

B. Design of the modified MacPherson strut suspension

1. A spring and lower control arm arrangement similar to those in a short and long arm suspension is used.

2. A strut assembly is used in place of an upper control arm and ball joint. No spring is attached to the strut. In addition to taking the place of the upper control arm, the strut acts as the shock absorber.

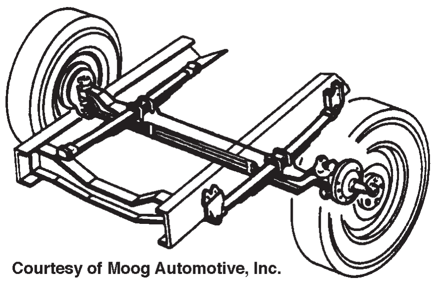


IV. Straight axle front suspension

A. Straight axle front suspensions are usually found only on large trucks.

B. Design of the straight axle front suspension

1. In straight axle front suspension, each end of a solid forged steel beam axle is connected to leaf springs via U-bolts. A spring hanger bracket connects the front of the spring to the frame via a rubber bushing in the spring eye. A shackle connects the rear of the spring to the frame. The shackle allows the spring to change its length as it flexes.



Courtesy of Moog Automotive, Inc.

2. Special hardened steel pins, called kingpins, connect the steering knuckles to each end of the axle. The kingpins are pressed into the axle; the steering knuckles pivot on the kingpin in bushings.

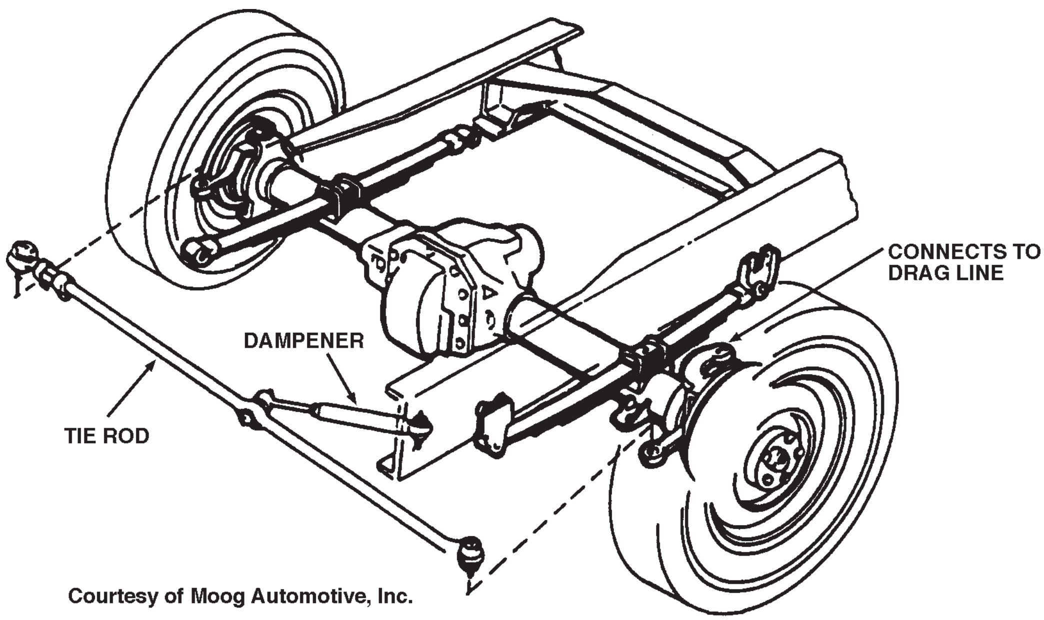
3. Thrust bearings, inserted between the axle and spindle, support the vehicle load. A shock absorber is connected to the vehicle's frame and to each end of the axle.

V. Four-wheel-drive front axle suspension

A. The four-wheel-drive front axle suspension is widely used in today's four-wheel-drive vehicles.

B. Design of the four-wheel-drive front axle suspension

1. The four-wheel-drive front axle suspension is similar to the straight axle front suspension. In place of the solid beam axle, however, a solid drive axle housing is used.



Courtesy of Moog Automotive, Inc.

2. The four-wheel-drive front axle uses either leaf or coil springs.

   a. The leaf spring connections are similar to those in a straight axle.

   b. When coil springs are used, special arms — called radius arms — maintain the position of the axle assembly. The radius arms are mounted on the vehicle frame via special rubber bushings. The arms extend forward and are connected to the outer ends of the axle housing.

3. The steering knuckles are usually attached to and pivot on the axle housing via the upper and lower ball joints.

4. Shock absorbers are mounted between the vehicle's frame and the axle housing.

VI. Twin I-beam front suspension

A. The twin I-beam front suspension system combines the strength of a straight axle design with the ride and handling benefits of an independent suspension.

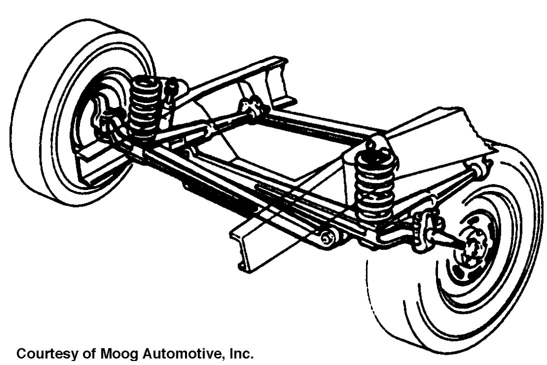
B. The twin I-beam front suspension uses two forged I-beam axles. One end of each axle is attached to one spindle and a radius arm. The other end of each axle is connected to the frame via a pivot bushing and bolt.

C. Each steering knuckle is attached to the axle through a kingpin. The kingpin is installed in the steering knuckle via bushings and is pressed into the end of the axle. A thrust bearing between the axle and the spindle supports the load on the axle.

D. Radius arms are used to control the forward and backward movement of the axles. The arms are mounted from the outer end of each axle rearward to the vehicle frame. Rubber bushings are located at the frame mounting points. The radius arms allow for the up and down movement of the suspension.

E. Coil springs are mounted between spring pockets on the vehicle's frame and axle.

F. Shock absorbers are used at each wheel to dampen spring movement.



Courtesy of Moog Automotive, Inc.

AS1-L2-UVIII

MODULE: STEERING AND SUSPENSION SYSTEMS

TYPES OF SUSPENSION SYSTEMS

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. An independent front suspension that uses an upper and lower control arm is called what?

2. If the spring is positioned on the lower control arm, which ball joint carries the load?

3. MacPherson strut front suspensions use how many control arms per wheel?

4. In a modified MacPherson strut front suspension, what component rests on the lower control arm?

5. What device is used to connect a straight axle to the steering knuckles?

6. What component fits inside the strut tube of a MacPherson strut unit?

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VIII: FRONT SUSPENSION SYSTEM DESIGNS

LESSON 3: THE DESIGN AND FUNCTION OF WHEEL BEARINGS

I. Tapered wheel bearings

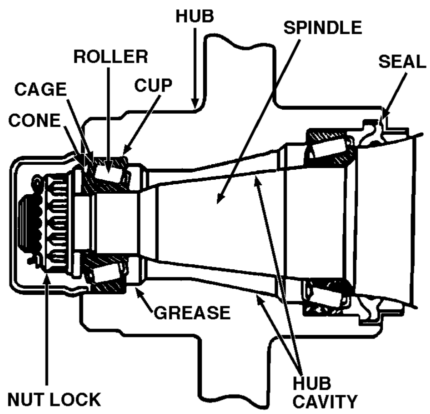
   A. Wheel bearings are used at each wheel hub to minimize rolling resistance and to allow the wheels to rotate freely. On rear-wheel-drive vehicles, the most commonly used front-wheel bearing is the tapered roller bearing. The tapered roller wheel bearing design is also used on the rear wheels of many front-wheel-drive vehicles. The tapered roller bearing is favored because of its load-carrying ability.

   B. Design of the tapered roller wheel bearings

      1. The typical rear-wheel-drive vehicle has dual tapered roller bearings mounted on a stationary spindle at each wheel. The outer wheel bearing is normally smaller than the inner one. The bearings are positioned so that the tapers face each other; this positioning holds the wheel hub in lateral alignment.

      2. Tapered roller bearings consist of an outer cone (also called a race), an inner cone, a cage (also called a separator), and the tapered rollers. All bearing surfaces are very hard. The rollers roll on the flat surfaces of the inner and outer cones. The bearing cage (made of steel or plastic) maintains the proper spacing between the rollers. The outer cones are pressed into the hub. The bearing cage also holds the tapered rollers against the inner cone.

         (**NOTE:** Ball bearings, which are similar in design to tapered bearings, are used on some vehicles. These are generally found on older model vehicles.)



3. Spindle construction

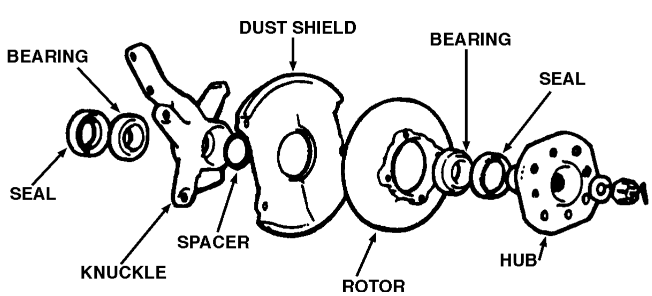
    a. A hex nut is threaded onto the spindle to retain the bearings and maintain their proper adjustment. A cotter pin locks the nut in place.

    b. The outer end of the spindle is slotted, which allows it to accept a special tabbed washer. The washer keeps the spinning motion of the bearing from being transferred to the retaining nut. The washer is installed over the spindle before the nut is installed.

    c. The spindle connects to the wheel via the wheel hub and bearings, which ride on the spindle. The spindle is either connected to or integral with the steering knuckle.

    d. High-temperature wheel bearing grease, packed between the bearings and hub, provides lubrication.

C. A somewhat modified version of the tapered roller bearing design is used on the front wheels of some front-wheel-drive vehicles. In the modified design, a selective spacer placed between the bearings allows for their adjustment.

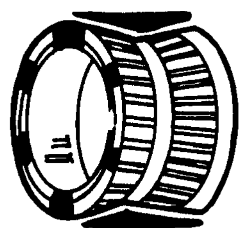


D. When the tapered bearings are used on front-wheel-drive vehicles, the outer bearing races are pressed into the steering knuckle and the wheel hub is pressed into the inner races.

II. Double row ball or roller bearings

A. A type of wheel bearing that is used quite extensively on both the front and rear wheels of today's front-wheel-drive vehicles is the double row ball or roller bearing.

B. The double row ball or roller bearing has inner and outer races with two parallel grooves in which two rows of balls or rollers roll. The bearing is nonadjustable and permanently lubricated and sealed. On some vehicles, the bearing is integral with the wheel hub. A bearing and a hub that are integral must be serviced as a complete unit.



AS1-L3-UVIII

MODULE: STEERING AND SUSPENSION SYSTEMS

WHEEL BEARINGS

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. What type of wheel bearing is most commonly used on rear-wheel-drive vehicles?

2. List the four major parts of a tapered roller wheel bearing.

3. The outer wheel bearing cones are pressed into what component?

4. The wheel bearings are supported by what component?

5. Many of today's front-wheel-drive vehicles use what kind of tapered roller or ball bearings?

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT IX: SLA SUSPENSION SYSTEM DIAGNOSIS AND LUBRICATION

UNIT OBJECTIVE

After completing this unit, the student should be able to measure vehicle ride height and determine necessary repairs, lubricate steering and suspension systems, and determine ball joint condition. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1.

I. Identify the procedures for determining vehicle ride height (Competencies S1 and U2, Part I of the Unit IX Test).

II. Identify the procedures for inspecting load-carrying and nonload-carrying ball joints (Competencies S2 and S6, Parts II and III of the Unit IX Test).

III. Identify the procedures for lubricating a suspension and steering system (Competency S2, Part II of the Unit IX Test).

IV. Demonstrate the ability to:

   a. Measure vehicle ride height (Competencies S1, S5, and U2, JS1-L1-UIX).

   b. Test ball joints (Competencies S2 and S6, JS2-L1-UIX).

   c. Lubricate a steering and suspension system (Competencies S2 and S6, JS3-L1-UIX).

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT IX: SLA SUSPENSION SYSTEM DIAGNOSIS AND LUBRICATION

CONTENTS OF THIS UNIT

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT IX: SLA SUSPENSION SYSTEM DIAGNOSIS AND LUBRICATION

LESSON 1: DIAGNOSING AND LUBRICATING AN SLA SUSPENSION SYSTEM

I. Vehicle ride height (also called curb height or chassis height)

A. If the springs of a vehicle become weak or broken, the vehicle will sag. This sagging throws off the front end geometry of the vehicle, resulting in poor handling and excessive tire wear. By measuring vehicle ride height, the technician can determine if the springs or other parts of the suspension system are broken.

B. Procedure for measuring ride height

(**NOTE:** Service manuals give ride height specifications and identify the points on the vehicle at which measurements should be taken. Make sure the vehicle is on a level surface when taking measurements.)

1. Inflate tires to recommended pressure.

2. Make sure the vehicle's tires are of the correct size and type.

3. Fuel tank should be full.

   (**NOTE:** Add weight to the vehicle to compensate for a fuel tank that is less than full.)

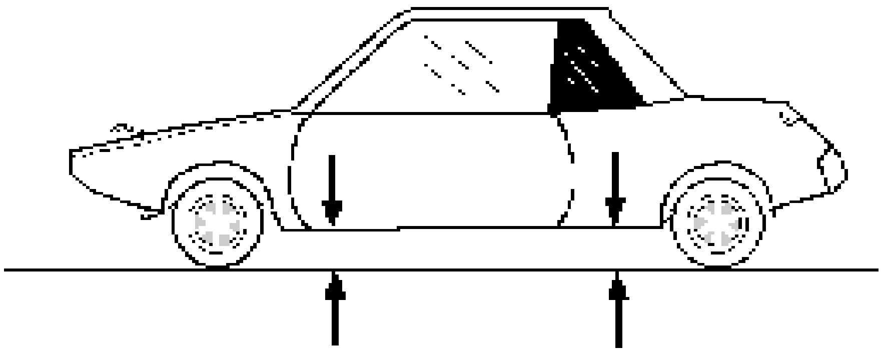
4. The vehicle should contain no passengers, luggage, or other nonessential cargo.

5. Clean all foreign material from the area at which the measurement is to be taken.

6. Jounce the vehicle vigorously and allow the suspension to settle.

7. Measure the vehicle at all points identified in the service manual. Compare the measurements with specifications in the service manual.

C. Incorrect ride height can be caused by severe damage to the frame or other suspension components. If the vehicle has no such damage, improper ride height is probably a result of a problem with the springs. Defective coil springs must be replaced in pairs. Torsion bar springs can sometimes be adjusted to achieve the correct ride height.



II. Inspecting ball joints (load-carrying and nonload-carrying) on SLA suspension systems

(**NOTE:** Nonload-carrying ball joints are also referred to as follower ball joints.)

(**NOTE:** Ball joints are inspected during alignment and routine suspension inspections.)

(**NOTE:** Under normal driving conditions the load-carrying ball joint is the joint which wears the fastest. However, always inspect both ball joints.)

A. Procedure for lifting a vehicle with SLA suspension to prepare for ball joint inspection

1. On coil under suspension systems, place the jack under the spring pocket of the lower control arm and lift the tire 2" off the ground.

2. On coil over suspension systems, place the jack under the frame cross member and lift the tire off the ground.

B. Procedure for inspecting the general condition of wear indicator and nonwear indicator ball joints (load-carrying)

1. Inspect the condition of the grease seal. Make sure the seal is not missing, torn, or split. A defective seal allows contaminants into the ball socket and will cause premature failure of the joint.

2. If the ball joint is drilled for a grease fitting or plug, make sure the fitting or plug is present. A missing fitting will cause the joint to fail.

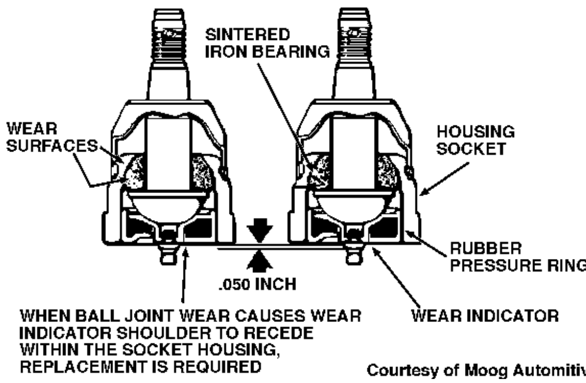
3. Make sure the castellated nut is tight on the tapered stud. Also make sure the cotter pin is installed correctly.

C. After inspecting the general condition of the load-carrying ball joint, the technician must determine if the joint is a wear indicator or a nonwear indicator before continuing the inspection. A wear indicator joint has a small shoulder protruding from the lower portion of the joint housing and can thus be distinguished from a nonwear indicator joint.

D. Procedure for inspecting a wear indicator ball joint (load-carrying)

1. The wear indicator joint should be inspected while it is loaded; therefore, make sure that the wheels support the car weight.

2. Examine the wear indicator ball joint carefully. If the joint's shoulder is flush with or completely receded into the housing, the joint is worn and should be replaced.



Courtesy of Moog Automitive, Inc.

E. Procedure for inspecting nonwear indicator ball joints (load-carrying)

1. Raise the vehicle and support it with jack stands to unload the ball joint.

   (**NOTE:** If the spring or torsion bar is on the lower control arm, place the jacks under the control arm as far outboard as possible. If the spring is on the upper control arm, place the jack stands under the frame.)

2. Following the procedure outlined below, check the joint for radial looseness. (**NOTE:** Some ball joints should not be checked for radial looseness. Consult the appropriate service manual before performing the below procedure.)

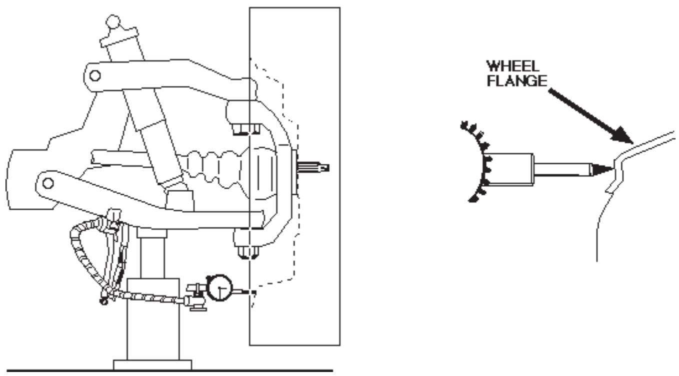
   a. Mount the dial indicator on the vehicle. Make sure the dial plunger rests on the wheel rim that is nearest to the ball joint to be checked.

      (**NOTE:** Use a dial indicator that is equipped with a special flexible arm and a mounting bracket capable of reaching into tight locations.)

   b. After the joint is unloaded, grasp the tire at the top and bottom and move it in and out. Observe the dial indicator reading.

   c. If the dial indicator reading exceeds manufacturer's specifications, move the tire in and out while an assistant observes the source of the looseness. Make sure the looseness is caused by the wheel bearing.

INSPECTION FOR HORIZONTAL MOVEMENT



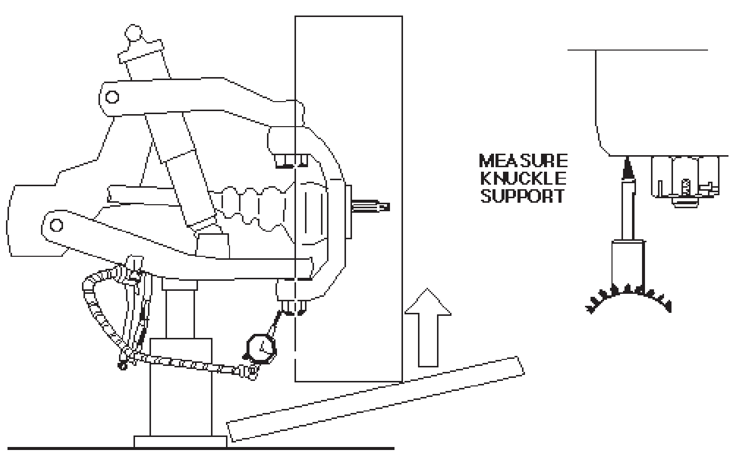
3. Following the procedure outlined below, check the ball joint for axial play.

   a. With the ball joint unloaded, clamp the dial indicator on the control arm. Place the plunger on the flat surface of the steering knuckle next to the ball joint stud. Clean dirt and grease from the part of the knuckle upon which the dial indicator will rest.

   b. Insert a pry bar between the wheel and floor. Pry the wheel upward and note the dial indicator reading. Pry only hard enough to detect any play in the ball joint.

   c. Compare the dial indicator reading to the manufacturer's specifications.

INSPECTION FOR VERTICAL MOVEMENT



F. Procedure for inspecting the general condition of wear indicator and nonwear indicator ball joints (nonload-carrying)

   1. Inspect the condition of the grease seal. Make sure the seal is not missing, torn, or split. A defective seal allows contaminants into the ball socket, resulting in premature failure of the joint.

2. If the ball joint is drilled for a grease fitting or plug, make sure the fitting or plug is present. A missing fitting will cause the joint to fail.

3. Make sure the castellated nut is tight on the tapered stud. Also make sure the cotter pin is installed correctly.

4. Make sure the ball joint is attached tightly to the control arm bolts or rivets.

G. Procedure for inspecting ball joints for looseness (nonload-carrying)

1. Place the dial indicator plunger against the edge of the wheel opposite the ball joint being checked.

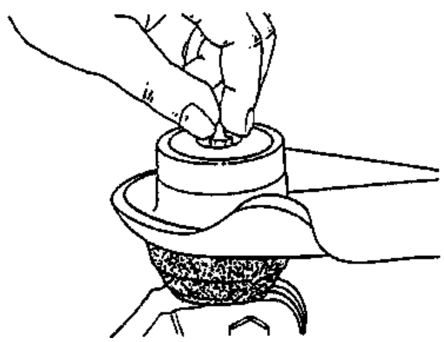
2. Grasp the tire and vigorously push and pull on it while watching the ball joint for movement.

3. Compare the reading on the dial indicator to the manufacturer's specifications.

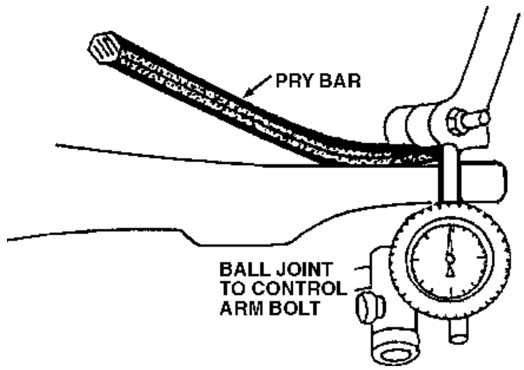
H. When inspecting ball joints on vehicles equipped with MacPherson struts, the technician can use the same procedures as listed above. Described in items "1" and "2" below, however, are two additional procedures for inspecting ball joints on some vehicles equipped with MacPherson struts.

(**NOTE:** Vehicles equipped with MacPherson struts use only load-carrying ball joints.)

1. With the weight of the vehicle resting on its tires, grasp the grease fitting and attempt to move it with the fingers. If the ball joint is worn, the grease fitting will move easily. If movement is noted, replace the ball joint.



2. Support the vehicle by the frame and allow the suspension to hang free. Place a dial indicator against the steering knuckle and insert a pry bar between the knuckle and control arm. Pry the steering knuckle and note the dial indicator reading. If the reading exceeds manufacturer's specifications, replace the ball joint.



III. Lubricating a suspension and steering system

(**NOTE:** Some steering joints are lubricated and sealed during assembly. Most ball joints and steering linkage joints, however, require periodic lubrication.)

A. Before lubricating a steering and suspension system, check the condition of all suspension joint seals. Replace any split, torn, or missing seals.

(**NOTE:** If the seal is an integral part of the joint, replace the entire joint.)

(CAUTION: Use a hand-operated, low-pressure grease gun. A high-pressure, air-operated gun can easily rupture seals, especially if used by a novice.)

B. To prevent contaminants from entering the joints, wipe all grease and dirt from each fitting. If the vehicle is equipped with plugs instead of fittings, remove each plug and install a temporary fitting. Reinstall the plugs after the joint is greased.

C. Snap the grease gun nozzle onto the fitting and force grease into the socket until the seal starts to swell. Wipe excessive grease from the joint.

(CAUTION: Do not continue to force lubricant into a socket after the seal starts to swell; doing so will rupture the seal. Make sure to use the proper grease. Most suspension and steering systems use an extreme pressure or EP grease.)

JS1-L1-UIX

MODULE: STEERING AND SUSPENSION SYSTEMS

MEASURING VEHICLE RIDE HEIGHT

Equipment:

Tape measure
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for measuring the vehicle's ride height. Make sure the procedure also records the points from which the ride height measurements are to be taken. Also make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, measure the vehicle's ride height. Do the tasks outlined below before taking the measurements.

   a. Inflate tires to the recommended pressure.

   b. Make sure the tires are of the proper size and type.

   c. Remove all unnecessary weight from the vehicle, such as luggage or other nonessential cargo.

      (**NOTE:** The fuel tank should be full when ride height measurements are taken. If the tank is not full, add equivalent weight to the vehicle. No one should sit in or lean on the vehicle while measurements are taken.)

   d. Clean all foreign material from the areas at which the measurements are to be taken.

   e. Jounce the vehicle vigorously, and allow the suspension to settle.

3. Measure the ride height of the vehicle at all 4 corners of the vehicle.

4. Record the ride height measurements below. If the height is not correct, suggest procedures for solving the problem.

JS2-L1-UIX

MODULE: STEERING AND SUSPENSION SYSTEMS

TESTING BALL JOINTS

Equipment:

Hoist
Floor jack
Hand tools
Dial indicator or ball joint gauge
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Place the vehicle securely on safety stands or lift with hoist.

   (CAUTION: Follow all the proper safety procedures and use the proper equipment when lifting a vehicle.)

3. Using a service manual or other information source, locate a procedure for inspecting the condition of the ball joints. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, inspect the ball joints. Use the chart below to indicate the condition of various ball joint parts.

   Grease seal

   OK_____ NOT OK_____

   Grease fitting

   OK_____ NOT OK_____

Stud nut/Cotter pin

OK_____ NOT OK___

Suggest repair procedures for any item marked "NOT OK" above.

4. Using a service manual or other information source, locate a procedure for lifting the vehicle to unload the loac-carrying ball joints. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

This procedure will only be used if necessary in step 5.

5. Lower the vehicle. Using a service manual or other information source, locate a procedure for evaluating the condition of the load-carrying ball joints. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procledure, evaluate the load-carrying ball joints. If necessary, unload the ball joints, using the procedure listed in number 4 of this job sheet. Record observations.

6. Using a service manual or other information source, locate a procedure for evaluating the condition of the nonload-carrying ball joints. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, evaluate the nonload-carrying ball joints. Record observations.

7. Record the specifications related to the ball joint movement. Compare this to the above tests. Based on the comparison, record the condition of the ball joints.

JS3-L1-UIX

MODULE: STEERING AND SUSPENSION SYSTEMS

LUBRICATING A STEERING AND SUSPENSION SYSTEM

Equipment:

Hoist
Grease gun
Hand tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Place the vehicle securely on safety stands or lift with hoist.

   (CAUTION: When lifting a vehicle, be sure to use the proper equipment and observe all applicable precautions.)

3. Record the type of lubricant recommended for the vehicle's steering and suspension.

   Recommended lubricant ________________________

4. Inspect all steering and suspension joint grease seals. If any seals are torn or missing, they should be replaced. Record observations.

5. Wipe all grease from each grease fitting. If plugs are used instead of fittings, install temporary fittings.

6. Apply grease to each fitting until grease begins to flow out of the bleed area at the base of the seal or until the seal starts to swell.

   (CAUTION: Do not continue to force lubricant into a socket after the seal starts to swell; doing so will rupture the seal.)

7. Apply a heavy film of grease to the steering stops on the steering knuckle and control arms.

8. Wipe excessive grease from all joints, reinstall plugs, and lower vehicle.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT X: SERVICING CONVENTIONAL FRONT SUSPENSION SYSTEMS

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose and replace worn front suspension components. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the procedures for inspecting shock absorbers (Competencies S4 and T4, Part II of the Unit X Test).

II. Identify the procedures for inspecting and replacing the stabilizer bar (Competency S4, Part II of the Unit X Test).

III. Identify the procedures for inspecting and replacing strut rods and bushings (Competency S6, Part III of the Unit X Test).

IV. Demonstrate the ability to:

 a. Inspect and replace front suspension shock absorbers (Competencies S1 and S4, JS1-L1-UX).

 b. Inspect and replace stabilizer bars and bushings (Competencies S1 and S4, JS2-L1-UX).

 c. Inspect and replace front suspension strut rods and bushings (Competency S6, JS3-L1-UX).

Lesson 2.

I. Identify the procedures for inspecting coil springs (Competencies S1 and S2, Part I of the Unit X Test).

II. Identify the procedures for replacing the coil spring on coil under suspension systems (Competencies S1 and S2, Part I of the Unit X Test).

III. Identify the procedures for removing and installing the coil spring on coil over suspension systems (Competency S2, Part I of the Unit X Test).

IV. Identify the procedures for replacing torsion bar springs (Competency S2, Part I of the Unit X Test).

V. Identify the procedures for servicing lower control arms (Competency S2, Part I of the Unit X Test).

VI. Identify the procedures for replacing upper control arms, cross shafts, and bushings (Competency S2, Part I of the Unit X Test).

VII. Identify the procedures for replacing the ball joint (Competency S2, Part I of the Unit X Test).

VIII. Demonstrate the ability to:

a. Inspect and replace front suspension coil springs (Competencies S1 and S2, JS1-L2-UX).

b. Inspect and replace front suspension torsion bar springs (Competencies S1 and S2, JS2-L2-UX).

c. Inspect and replace front suspension upper control arms and bushings (Competencies S1 and S2, JS3-L2-UX).

d. Inspect and replace front suspension lower control arms and bushings (Competencies S1 and S2, JS4-L2-UX).

e. Inspect and replace upper and lower ball joints (Competencies S1 and S6, JS5-L2-UX).

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT X: SERVICING CONVENTIONAL FRONT SUSPENSION SYSTEMS

CONTENTS OF THE UNIT

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT X: SERVICING CONVENTIONAL FRONT SUSPENSION SYSTEMS

LESSON 1: INSPECTING AND REPLACING FRONT SUSPENSION CONTROL COMPONENTS

(**NOTE:** Always replace a suspension fastener with a fastener of the same type and quality. Using an improper fastener could cause suspension failure. Always adhere to the manufacturer's torque specifications when assembling suspension systems.)

(**NOTE:** Never heat, quench, straighten, or weld a suspension part. Always replace any worn or damaged parts.)

I. Inspecting and replacing the shock absorber

A. Procedure for inspecting shock absorbers

1. Raise and secure the vehicle.

   (**NOTE:** Be sure to raise the vehicle by the frame; doing so allows the control arms to hang unsupported, thus extending the shock absorbers.)

2. Grasp the shock absorber and shake it. Note if it is mounted loosely. Inspect the condition of all rubber mounting bushings.

3. Inspect the piston rod and outer tube for excessive fluid leakage. A light film of fluid around the top of the shock absorber is considered normal.

   (**NOTE:** If heavy fluid loss is noted, make sure the leakage is not from another source such as the power steering or engine. If the source of the leak is questionable, clean the shock and recheck it after a road test.)

4. Inspect the shock tube and piston rod for signs of damage. Replace the shock if the tube is badly dented. Also check the piston rod for deep scratches, scoring, dents, or corrosion. Replace the shock if such damage is found.

   (**NOTE:** Small dents on the shock tube and light surface scratches on the rod are normal.)

B. Procedure for removing, testing, and replacing a front shock absorber (independent front suspension)

1. While holding the upper portion of the piston rod, loosen and remove the upper shock absorber retaining nut. Next, remove the washer and bushing.

(**NOTE:** Do not hold the piston rod with a wrench or pliers. Use the flats provided at the end of the piston rod.)

2. Raise the vehicle and secure it with safety stands.

3. Remove the bolts that attach the lower end of the shock absorber to the lower control arm; then remove the shock absorber.

   (**NOTE:** Once disconnected, a gas-charged shock will rapidly expand.)

   (CAUTION: Do not apply heat or flame to gas-charged shocks.)

C. Procedure for testing the operation of the shock

(**NOTE:** Extreme force is required to compress gas-charged shocks; therefore, the following tests are difficult to perform on gas-charged shocks.)

(**NOTE:** During the below procedure, only one accessible end of the shock needs to be disconnected from the vehicle.)

1. Fully extend and compress the piston rod. Make sure the shock functions smoothly and quietly.

   (**NOTE:** Shock action should produce a faint swishing sound.)

   (**NOTE:** The shock will not necessarily have the same resistance when reacting to jounce as when reacting to rebound.)

2. If the shock functions erratically or makes unusual noises, hold it upright and once again extend it fully. Next, turn the shock over and compress it fully. Repeat this action three times to expel any air trapped in the hydraulic cylinder.

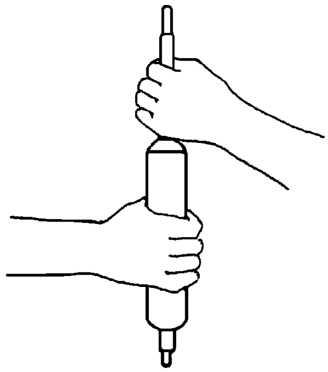
3. Position the shock upright in a vise.

4. Manually extend and compress the shock several times. If shock action is still erratic and/or noisy, replace the shock.

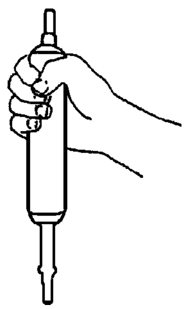
D. Procedure for bleeding air trapped in the shock

(**NOTE:** Always bleed any trapped air from the shock before installation.)

1. Hold the shock upright and fully extend it.



2. Invert the shock and slowly compress it as far as possible.



3. Repeat steps a and b several times.

E. Procedure for installing a front shock absorber

1. Fully extend the shock absorber and install the lower mounting washer and grommet on the upper end of the piston rod.

2. Insert the shock through the opening in the control arm and allow the piston rod stem to pass through the upper mounting hole.

3. Install the upper mounting grommet and washer; then install and tighten the retaining nut and bolt to the specified torque.

4. Install and tighten the nut and bolt that retain the lower end of the shock. Be sure to tighten the nut and bolt to the specified torque.

(**NOTE:** The procedure for installing a rear shock absorber is very similar to this procedure.)

II. Inspecting and replacing the stabilizer bar

A. Procedure for inspecting the stabilizer bar

1. Inspect the stabilizer bar for accident damage.

2. Inspect stabilizer bushings and links for deteriorated rubber or broken bolts and brackets.

3. Grasp the bar and shake it. Note any movement in the bushings. Worn bushings should be replaced.

B. Procedure for removing the stabilizer bar

1. Raise and secure the vehicle.

2. Remove the link bolts or brackets that connect the stabilizer to the control arms.

3. Remove the brackets connecting the stabilizer to the frame. Next, remove the stabilizer and bushings.

C. Procedure for reinstalling the stabilizer bar

1. Reverse the removal procedures to reinstall the bar.

2. Replace any worn or deteriorated bushings or broken brackets.

3. Install all bushings as directed by the manufacturer.

4. Tighten all fasteners to the factory-specified torque.

III. Inspecting and replacing strut rods and bushings

A. Procedure for inspecting strut rods

(**NOTE:** Unless damaged in an accident, the strut rod will seldom need to be replaced.)

1. Inspect the rod for signs of physical damage. A bent bar will cause the wheel alignment to be incorrect.

2. Inspect the strut rod bushings for wear or deterioration. Loose strut rod bushings can affect wheel alignment and cause noise during acceleration and braking. Worn or deteriorated bushings should be replaced.

B. Procedure for removing a strut rod and bushings

1. Raise the vehicle on a frame lift hoist or use a jack and place safety stands under the frame.

2. Remove the front strut rod nut.

3. Remove the bolts attaching the strut rod to the control arm.

4. Slide the control arm out of the frame and remove the old bushings.

C. Procedure for inspecting a strut rod after removal

1. Check the general condition of the bushings. Make sure the bushings are not cracked or deteriorated.

2. Make sure the strut rod is straight and its threads are in good condition.

D. Procedure for installing a strut rod and bushings

1. Install the bushings on the strut rod.

2. Insert the strut rod and bushings into the subframe. Elevate the rear of the rod so it is level. Tighten the front nut; doing so ensures that the bushings will seat correctly.

3. Pull down on the rear of the rod and connect it to the control arm.

4. Tighten the fasteners to the factory-recommended torque.

5. Lower the vehicle.

6. Check and adjust alignment as necessary.

   (**NOTE:** Care must be taken to locate the lower control arm in the correct position during installation of the strut rod or strut rod bushing.)

JS1-L1-UX

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING SHOCK ABSORBERS

Equipment:

Hoist
Hand tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Place the vehicle securely on safety stands or lift with a hoist.

   (CAUTION: Follow all the proper safety procedures and use the proper equipment when lifting a vehicle.)

3. Carefully inspect the shock absorbers. Complete the chart below.

Secureness of mounting	OK_____	NOT OK_____
Condition of rubber bushings	OK_____	NOT OK_____
Excessive fluid leakage	OK_____	NOT OK_____
Condition of piston rod and tube	OK_____	NOT OK_____

   If any of the above items were marked "NOT OK," suggest appropriate repairs.

4. Following the procedure outlined below, remove the shock absorber.

    a. Hold the piston rod to keep it from turning. Remove the upper shock absorber retaining nut, washer, and rubber bushing.

    (**NOTE:** Do not hold the piston rod with a wrench or pliers. Use the flats provided at the end of the piston rod.)

    b. Remove the bolts holding the lower end of the shock absorber to the lower control arm; then remove the shock absorber.

5. Extend and compress the piston rod through several full strokes; then complete the chart below.

    (**NOTE:** Extreme force is required to compress gas-charged shocks; therefore, it may be difficult to perform this test on gas-charged shocks.)

Smooth action	OK_____	NOT OK_____
Noise	OK_____	NOT OK_____
Resistance to movement in both directions	OK_____	NOT OK_____
Shock expands when released from compressed position (gas-charged only)	OK_____	NOT OK_____

    If any of the above items were marked "NOT OK," suggest appropriate repairs.

6. Hold the shock in an upright position and fully extend it. Next, turn the shock over and fully compress it. Repeat this action three times to expel any air trapped in the hydraulic cylinder.

7. Once again extend and compress the piston rod through several full strokes and complete the chart below.

Smooth action	OK_____	NOT OK_____

Noise	OK_____	NOT OK_____
Resistance to movement in both directions	OK_____	NOT OK_____
Expansion of gas-charged shock when released from compressed position	OK_____	NOT OK_____

If any of the above items were again marked "NOT OK," suggest appropriate repairs.

8. Following the procedure outlined below, install the shock absorber.

   a. Using an appropriate service manual, determine and record in the space below all torque specifications related to shock absorber installation.

   b. Using the procedure described in step 6 of this job sheet, bleed any air trapped in the shock absorber.

   c. Fully extend the shock absorber and install the lower mounting washer and grommet on the piston rod.

   d. Insert the shock through the opening in the control arm and allow the piston rod stem to pass through the upper mounting hole.

   e. Install the upper mounting grommet and washer; then install and tighten the retaining nut to the specified torque.

   f. Install and tighten the bolts that retain the lower end of the shock to the specified torque.

   g. Lower the vehicle.

JS2-L1-UX

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING STABILIZER BARS AND BUSHINGS

Equipment:

Hoist
Hand tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Jounce the vehicle and note any noise produced by the stabilizer assembly. Record observations.

3. Place the vehicle securely on safety stands or lift with hoist.

   (CAUTION: Follow all the proper safety procedures and use the proper equipment when lifting a vehicle.)

4. Visually inspect the condition of the stabilizer bar, bushings, and links. Complete the chart below.

   Condition of the stabilizer bar

   OK_____ NOT OK_____

   Condition of the stabilizer bar bushings

   OK_____ NOT OK_____

   Condition of mounting
   brackets and links

   OK_____ NOT OK_____

If any of the above items were marked "NOT OK," suggest appropriate repairs.

5. Following the procedure outlined below, remove the stabilizer bar.
   a. Remove the link bolts or brackets that attach the stabilizer to the control arms.

   b. Remove the brackets that attach the stabilizer to the frame and remove the stabilizer and bushings.

6. Inspect the condition of the bushings, brackets, and links. Record observations.

7. Following the procedure outlined below, install the stabilizer.

   a. Determine and record below all torque specifications related to the installation of the stabilizer.

   b. Reverse the removal procedures to install the stabilizer.

   c. Replace all damaged or missing parts as directed by the instructor.

   d. Lower the vehicle.

JS3-L1-UX

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING STRUT RODS AND BUSHINGS

Equipment:

Hoist
Hand tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Place the vehicle securely on safety stands or lift with a hoist.

   (CAUTION: Follow all the proper safety procedures and use the proper equipment when lifting a vehicle.)

3. Inspect the condition of the strut rods and bushings. Complete the chart below.

   Strut rods OK_____ NOT OK_____

   Strut bushings OK_____ NOT OK_____

   If any of the above items were marked "NOT OK," suggest appropriate repairs.

4. Using a service manual or other information source, locate a procedure for removing the strut rods and bushings. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, remove the strut rods and bushings. Record observations.

5. Inspect the strut rod and bushings. Record observations.

6. Using a service manual or other information source, locate a procedure for isntalling the strut rods and bushings. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, install the strut rods and bushings. Record observations.

7. Lower the vehicle. Check and reset all wheel alignment angles as necessary. See the instructor for wheel alignment procedures.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT X: SERVICING CONVENTIONAL FRONT SUSPENSION SYSTEMS

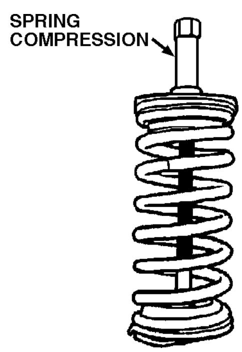
LESSON 2: INSPECTING AND REPLACING FRONT SUSPENSION SPRINGS, BALL JOINTS, AND CONTROL ARMS

I. Inspecting coil springs

A. Always make sure the vehicle is at its proper ride height before checking the coil springs. The springs should be checked for collapsed or broken coils. The coils should be checked for shiny spots, which indicate coil spring clash (coils hitting together during jounce). Coil spring clash results from weak springs or shock absorbers.

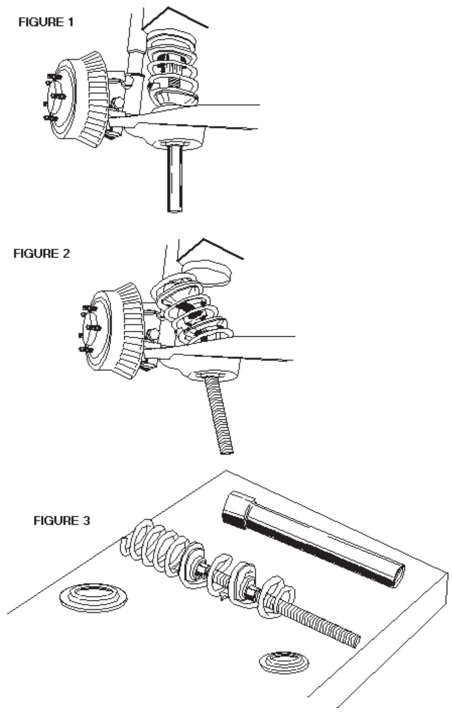
B. Make sure to follow the proper procedure and use the proper tools when servicing coil spring suspension systems. A compressor tool is required to remove and replace some springs.

(CAUTION: When servicing coil springs, use only approved spring compressing tools. Compressing a spring with the wrong tool could result in serious personal injury.)



II. Replacing the coil spring on coil under suspension systems (the spring on the lower control arm)

(**NOTE:** Procedures for removing coil springs vary from manufacturer to manufacturer. Some procedures call for special tools to ensure the safe removal of the springs. The below procedures are general and will not apply to all springs. Always refer to the proper service manual for the appropriate procedure.)



A. Procedure for removing coil springs

1. Raise the vehicle and place safety stands under the frame.

2. Remove the wheel and tire assembly from the vehicle.

3. Remove the shock absorber from the vehicle.

4. Install the spring compressor. Compress the spring according to procedures issued by either the vehicle or compressor manufacturer.

5. Remove the compressed spring from the vehicle.

6. Measure the length of the compressed spring. Note the positioning of the compressor on the spring. (The compressor must be positioned in the same way on the new spring.) Remove the spring compressor.

B. Procedure for inspecting coil springs and mountings

1. Disconnect the control arm at all points and then clean the spring mounting pads.

2. Inspect the control arm for signs of cracks and other damage.

3. Inspect the condition of the stud and the tapered hole in the steering knuckle. Replace any worn parts.

4. Inspect the condition of the control arm bushings and bolts. Replace any worn or damaged pieces.

5. Inspect the condition of the shock absorber. If one shock is found to be defective, replace both shocks.

6. Inspect the condition of any disconnected stabilizer and strut rod bushings. Replace them as necessary.

C. Procedure for reinstalling a coil suspension spring

1. Install the spring compressor on the new spring. Compress the new spring to the same length as the old spring. If the old spring used an insulator pad, transfer it to the new spring.

2. Install the compressed spring. Next, decompress the spring until it is properly seated. Remove the compressor tool.

3. Reconnect the shock absorber and the wheel.

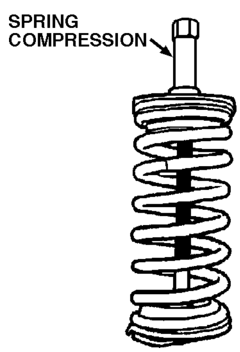
4. When spring installation is completed, move the vehicle at least 30 feet and park it on a flat, level surface. Jounce the vehicle several times. Allow the vehicle to settle out and check the chassis height.

5. Check and reset all alignment angles as necessary.

III. Removing and installing the coil spring on coil over suspension systems (spring on upper control arm)

A. Procedure for removing a coil spring

(**NOTE:** This procedure calls for a special spring compressing tool.)



1. Remove the shock absorber and upper shock mounting bracket as a single unit.

2. Raise the vehicle and place the safety stands under the control arms.

3. Remove the front wheel.

4. If necessary remove the rubber rebound bumper bracket.

5. Install the spring compressor. Compress the spring according to procedures issued by either the vehicle or the compressor manufacturer.

6. Remove the compressed spring from the vehicle.

7. Measure the length of the compressed spring. Note the positioning of the compressor on the spring. (The compressor must be positioned in the same way on the new spring.) Remove the spring compressor.

B. Procedure for installing the coil spring

1. Install the spring compressor on the new spring. Compress the new spring to the same length as the old spring. If the old spring used an insulator pad, transfer it to the new spring.

2. Install the compressed spring. Next, decompress the spring until it is properly seated. Remove the compressor tool.

3. Reconnect the shock absorber, the rebound bumper bracket, and the wheel.

4. When spring installation is completed, move the vehicle at least 30 feet and park it on a flat, level surface. Jounce the vehicle several times. Allow the vehicle to settle out and check the chassis height.

5. Check and reset all alignment angles as necessary.

IV. Replacing torsion bar springs

(**NOTE:** Procedures for torsion bar removal and replacement vary considerably, depending on the design of either the vehicle or bar. The following procedure is, therefore, very general. Consult an appropriate service manual to obtain the specific procedures for the vehicle to be serviced.)

A. Procedure for removing a torsion bar spring

1. Raise the vehicle and place safety jacks under the frame. Make sure the wheels are in the full rebound position.

2. Turn the torsion bar anchor, adjusting bolt counterclockwise to release the load on the torsion bar.

(**NOTE:** If removing transverse torsion bars, release the tension on both bars.)

3. Remove the torsion bar retainers and brackets; then remove the torsion bar.

B. Procedure for inspecting a torsion bar

1. Inspect the seal and replace it if damaged.

2. Inspect torsion bar for nicks or scoring. Dress down any nicks or scoring to remove sharp edges. Paint repaired areas with a rust preventative.

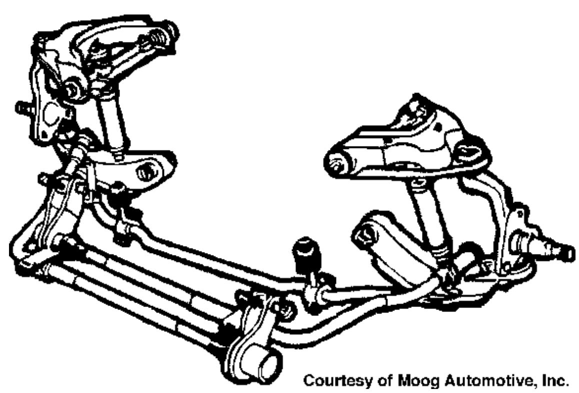
3. Inspect all mountings and bushings. Also inspect the adjusting bolt assembly. Replace all worn or damaged parts.

C. Procedure for reinstalling and adjusting a torsion bar

1. Reverse the removal procedure in order to reinstall the torsion bar.

2. After installation, turn the adjusting bolt clockwise to place a load on the torsion bar.

3. Lower vehicle and turn the adjusting bolt to achieve the correct front suspension height.



V. Servicing lower control arms

A. Procedure for inspecting the lower control arm

1. Thoroughly clean the control arm.

2. Inspect the control arm carefully for cracks and other damage. Replace the control arm if defects are found.

3. Inspect the condition of the lower control arm bushings. Replace any worn or deteriorated bushings.

B. Procedure for removing lower control arms

1. Raise the vehicle and place safety stands under the frame. (If spring is on the upper control arm, place a wood block between the upper arm and the side rail before raising the vehicle.)

2. Remove the coil spring as outlined previously. (If the spring is on the upper control arm, the spring will not have to be removed.)

3. Using a taper breaker, disconnect the control arm from the ball joint.

4. Remove the control arm to the frame attaching bolts. (If the spring is on the upper arm, mark the position of the upper arm alignment cams.)

5. Lower the control arm out from under the vehicle.

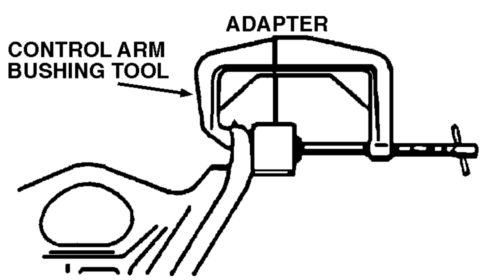
C. Procedure for replacing lower control arm bushings

1. Place the control arm in a vise. Be careful not to crush the control arm in the vise.

2. Using a proper removal tool, force the old bushing(s) from the control arm.

3. Using a proper tool or press, install the new control arm bushing(s).

(**NOTE:** During bushing removal and installation, support the inside area of the control arm with a suitable spacer; doing so will ensure that the arm is not crushed or distorted.)



D. Procedure for installing a lower control arm

1. Reverse the removal procedures to reinstall the coil spring and control arm.

2. If the spring is on the upper arm, use the marks made before disassembly to position the alignment cams.

3. Tighten all fasteners to specified torque.

4. Check and adjust front-wheel alignment.

VI. Replacing upper control arms, cross shafts, and bushings

A. Procedure for inspecting upper control arms

1. Make sure upper control arm bushings (made of rubber) are not distorted, off center, loose, or excessively cracked.

(**NOTE:** Light cracks in the rubber bushing may be acceptable. If light cracks are discovered, inspect the bushing more closely to ensure that no other problems exist.)

2. Inspect the seals on metal bushings. Make sure that the metal bushings produce no unusual noise. Jounce the vehicle and listen for squeaking noises in the upper control arms. Noise is a sign of friction and wear.

3. Make sure that the nuts on the ends of the cross shaft are tight. These nuts sometimes become loose and allow the bushings to work their way out of the control arm.

B. Procedure for removing the upper control arm

1. Raise the vehicle and support the front of the vehicle with safety stands.

   (CAUTION: The positioning of the safety stands depends on the location of the spring. If the spring rests on the upper control arm, place the safety stands under the frame. If the spring rests on the lower control arm, place the safety stands between the spring seat and the ball joint.)

2. Remove the tire and wheel assembly.

3. Following the procedure outlined below, remove the upper ball joint from the steering knuckle.

   (**NOTE:** If the spring is on the upper control arm, use a spring compressor to relieve the spring tension. This procedure was described in the spring removal section above. The spring needs only to be compressed, not removed.)

   a. Remove the cotter pin from the tapered stud of the upper ball joint.

   b. Clean the threads on the end of the stud and loosen the nut two or three turns. Do not remove the nut at this time!

   c. Using a ball joint taper breaker, separate the stud from the knuckle.

   d. Remove the ball joint stud nut.

4. Remove control arm cross shaft nuts.

   a. Remove any alignment shims and note their position for reassembly.

   b. If a slotted alignment adjuster is used, scribe marks on the adjuster to show the position of the cross shaft. The marks will be referred to for reassembly.

5. Remove the control arm assembly from the car.

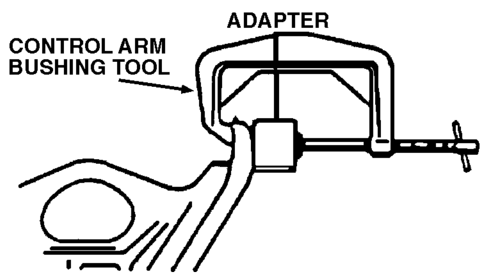
C. Procedure for replacing control arm bushings and shafts (rubber bushings)

1. Rubber bushings may be replaced by pressing or driving them in and out.

2. Clamp the cross shaft to a bench vise to support the control arm.

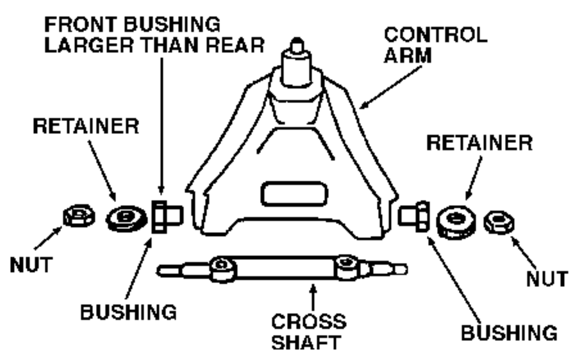
3. Remove the nuts from the ends of a cross shaft.
(**NOTE:** Before removing the bushings, note their position in the control arm. Most bushings are pressed into the control arm until they contact a shoulder. Some bushings, however, are pressed to a specific depth. If the bushing does not contact a shoulder, measure and record the depth at which it is pressed into the control arm.)

4. Using a special bushing removal tool, press the bushings from the control arm. The bushings can also be driven out with a pneumatic impact chisel.

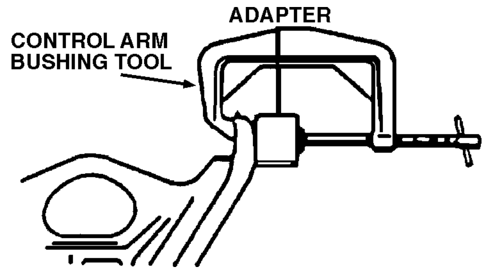


5. Inspect the control arm for cracks and damage. Also inspect the arm for wear at the bushing holes. Replace any worn or damaged parts.

6. Inspect the cross shaft for wear at the bushing pivot points.



7. Using a suitable tool, press the bushings into the control arm. Follow the procedure outlined below.



a. Install the shaft in the arm before pressing the bushings into place.

b. If pressure is being applied to the entire arm during assembly, place a spacer on the inner portion of the arm to prevent damage.

c. The bushings may be driven into the control arm if a suitable driver is available. Support the control arm to prevent damage.

d. Put the nuts on the cross shaft ends but do not tighten them completely. To prevent preloading the bushings, the nuts should be tightened after the arm has been installed and the vehicle is at curb height.

D. Procedure for replacing metal control arm bushings and shafts

1. Clamp the cross shaft in a vise to support the control arm.

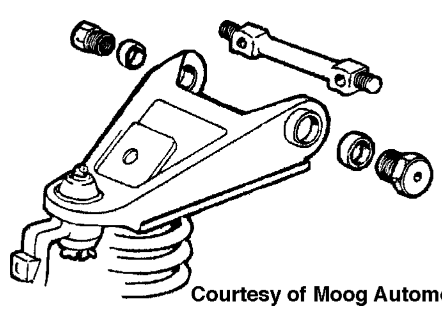
2. Loosen and remove the bushings with a socket and a breaker bar.

3. Position the shaft in the arm, apply grease to the new bushings and o-rings, and install the bushings on the shaft and arm. (Allow the bushings to remain loose at this point in the procedure.)

   a. Once the bushings are started into the control arm, locate and mark the center point between the mounting holes and the center of the control arm.

   b. Alternately tighten the bushings, keeping the reference marks perfectly aligned.

   c. Tighten the bushings to the specified torque and then lubricate them.



Courtesy of Moog Automotive, Inc.

E. Procedure for installing the control arm

1. To reinstall the control arm assembly, simply reverse the installation procedures.

2. Put alignment shims in the same position that they were in before removal. If a slotted alignment adjuster is used, align the cross shaft with the scribe marks made during removal.

3. After the arm is installed, lower the vehicle. Jounce the vehicle and allow it to settle to curb height; then tighten the cross shaft nuts to the specified torque.

   (**NOTE:** Failure to lower the vehicle before tightening the cross shaft nuts will preload the rubber bushings, causing them to twist excessively.)

4. Check and adjust wheel alignment as necessary.

VII. Replacing the ball joint

A. Ball joints are usually mounted in one of the three ways listed below.

1. The joint may be threaded into the control arm.

2. The joint may be riveted or bolted to the control arm.

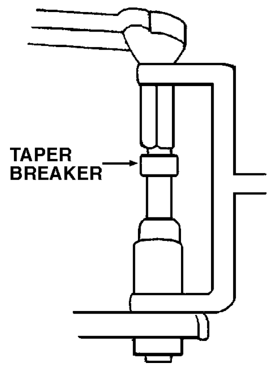
3. The joint may be pressed into the control arm.

   (**NOTE:** Service procedures vary for different types of ball joints.)

B. Special tools for ball joint service

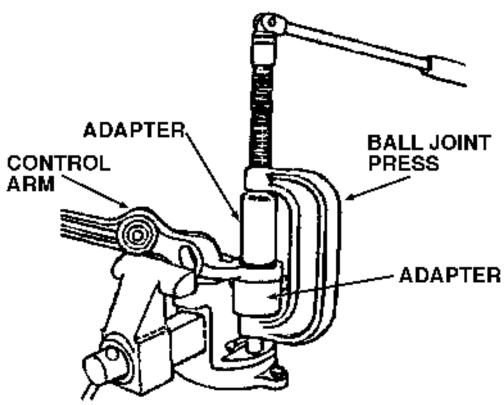
1. Most ball joints fit into the steering knuckle via a tapered stud arrangement similar to those used in steering linkages. A special taper-breaking tool should be used to remove the ball joint.

   a. One common taper-breaking tool is a screw press arrangement that fits between the upper and lower ball joint studs. As the nut on the screw is turned, the tool expands, forcing the stud out of the hole. Rapping the steering knuckle at the ball joint with a hammer while the stud is under pressure will release the taper.



b. A pickle fork can also be used to remove the ball joint. The pickle fork, however, will force the stud out of the hole as it is driven inward, thus destroying the joint.

2. A special tool is often needed to remove and replace press fit ball joints. The most common such device is a large C-clamp tool. Using different adapters that fit different ball joints, the C-clamp tool creates the force needed to remove and replace the press fit joints.



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C. Procedure for removing and replacing a load-carrying ball joint (spring on lower control arm)

1. Raise the vehicle and place jack stands under the lower control arm.

   (**NOTE:** Place a jack stand under the lower control arm at the spring seat to unload the ball joint and to retain the spring.)

   (CAUTION: The spring and control arm must always be retained during ball joint removal and installation.)

2. Remove the tire and wheel assembly.

3. Remove the cotter pin from the ball joint stud. Loosen the castellated nut two or three turns. Do not remove the nut at this time!

a. Using the proper ball joint taper breaker, break the taper between the ball joint stud and steering knuckle.

b. Once the stud is free, remove the nut.

c. Lift the spindle assembly so it is free of the ball joint. Place a wood block between the frame and upper control arm to keep the spindle out of the way.

5. Using the proper tool, remove the ball joint from the lower control arm.

a. Use a special tool to force press fit joints out from the control arm.

b. Use the proper socket to remove threaded ball joints from the control arm.

c. Use a chisel to remove a riveted ball joint. The chisel should be used only to cut the rivets. Be careful not to damage the control arm with the chisel.

6. Thoroughly clean and inspect the tapered hole in the steering knuckle. If the hole is damaged or worn, replace the steering knuckle. Clean the ball joint mounting area of the control arm. Inspect the area for cracking or distortion. Replace the arm if any problems are found.

7. Reverse the removal procedure to install the ball joints in the control arm. Tighten threaded ball joints to the specified torque.

(**NOTE:** Riveted ball joints are usually replaced with bolts instead of rivets.)

8. Install the ball joint stud in the steering knuckle.

a. Install the castellated nut on the stud and tighten to specified torque.

b. Install a new cotter pin in the tapered stud.

(**NOTE:** Never back off the castellated nut to align holes; always tighten to the next hole.)

c. If the ball joint is equipped with a lubrication fitting or plug, lubricate the ball joint with the factory-specified grease.

D. Procedure for removing and replacing a nonload-carrying ball joint (spring on lower control arm)

1. Raise the front of the vehicle and place safety stands under the lower control arms. Because the weight of the vehicle is used to relieve spring tension on the upper control arm, place the stands as far outboard as possible to provide maximum leverage.

(CAUTION: The spring and control arm must be retained throughout the removal and installation of the ball joint. Safety stands must, therefore, remain under the lower control arm at all times during these procedures.)

2. Remove the wheel and tire assembly.

3. Remove the cotter pin from the ball joint stud. Loosen the castellated nut two or three turns. Do not remove the nut at this time!

    a. Using a taper-breaking tool, break the taper between the ball joint stud and steering knuckle. Make sure to use the proper taper-breaking tool to avoid damaging the components.

    b. Once the stud is free, remove the nut.

    c. Lift the upper control arm so it is free of the steering knuckle. Support the steering knuckle to prevent damage to the brake line.

4. Using the same procedure outlined for the load-carrying ball joint, remove the ball joint from the control arm.

5. Thoroughly clean and carefully inspect the tapered hole in the steering knuckle. If the hole is damaged or worn, the steering knuckle must be replaced. Clean the ball joint mounting area of the control arm. Inspect for cracking or distortion and replace the arm if problems are found.

6. Install the ball joint in the control arm by reversing the removal procedures.

7. Remove the temporary support from the steering knuckle and reattach the steering knuckle to the control arm.

    a. Install and tighten the castellated nut to the specified torque.

    b. Install a new cotter pin in the tapered stud.

    (**NOTE:** Never back off the castellated nut to align holes. Always tighten to the next hole.)

    c. If the ball joint is equipped with a lubrication fitting or plug, lubricate the ball joint with the factory-specified grease.

E. The procedure for replacing ball joints on vehicles with the spring on the upper control arm is similar to that for one with the spring on the upper ball joint with the exception of coil spring retention. Consult the appropriate service manual for procedures for replacing ball joints on vehicles which have the spring on the upper ball joint.

JS1-L2-UX

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING COIL SPRINGS

Equipment:

Hand tools
Hoist
Floor jack
Specialty tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Place the vehicle securely on safety stands or lift with hoist.

   (CAUTION: Follow all the proper safety procedures and use the proper equipment when lifting a vehicle.)

3. Inspect the coil spring. Note any broken or collapsed coils. Also note any evidence of coil clash. Record observations.

4. Using a service manual or other information source, locate a procedure for removing the coil spring. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, remove the coil spring. Record observations.

(CAUTION: Follow the manufacturer's instructions carefully during removal and installation; failure to do so could result in serious personal injury.)

5. Inspect the coil spring and related components. Complete the chart below.

a.	Control arms	OK_____	NOT OK_____
b.	Stud and the tapered hole in the steering knuckle	OK_____	NOT OK_____
c.	Disconnected control arm bushings and bolts	OK_____	NOT OK_____
d.	Shock absorber	OK_____	NOT OK_____
e.	Disconnected stabilizer and strut rod bushings	OK_____	NOT OK_____

If any of the above items were marked "NOT OK," describe the problem and suggest appropriate repairs.

6. Using a service manual or other information source, locate a procedure for installing the coil spring. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, install the coil spring.

a. Clean the spring mounting pads before installation.

b. Be sure to reinstall any rubber insulators before installing the spring.

c. Tighten all fasteners to specified torque.

7. Lower the vehicle. Move the vehicle (at least 30 feet) to a flat, level surface. Jounce the vehicle several times. Allow it to settle out and check chassis height.

8. Check and reset all alignment angles as necessary. See the instructor for wheel alignment procedures.

JS2-L2-UX

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING TORSION BAR SPRINGS

Equipment:

Hoist
Hand tools
Specialty tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for removing the torsion bar spring. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, remove the torsion bar spring. Record observations.

   (CAUTION: Follow the manufacturer's instructions carefully during removal and installation; failure to do so could result in serious personal injury.)

3. Inspect the torsion bar spring and related components. Fill out the chart below.

Seal (if used)	OK_____	NOT OK______
Torsion bar (look for nicks or scoring)	OK_____	NOT OK______
Adjusting bolt assembly, mounts, and bushings	OK_____	NOT OK_____

If any of the above items were marked "NOT OK," describe the problem and suggest appropriate repairs.

4. Using a service manual or other information source, locate a procedure for installing the torsion bar spring. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, install the torsion bar spring.

a. Clean spring mounting points before installation.

b. Replace all damaged or missing parts as directed by the instructor.

c. Tighten all fasteners to specified torque.

5. Using a service manual or other information source, locate a procedure for adjusting the torsion bar ride height. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, adjust the torsion bar ride height. Record observations.

6. Check and reset all alignment angles as necessary. See the instructor for wheel alignment procedures.

JS3-L2-UX

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING UPPER CONTROL ARMS AND BUSHINGS

Equipment:

Hand tools
Hoist
Ball joint taper breaker
Specialty tools

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Inspect the condition of the control arm and bushings. Fill out the below chart.

   Control arm bushings OK_____ NOT OK_____

   Cross shaft nuts OK_____ NOT OK_____

   Control arm condition OK_____ NOT OK_____

   If any of the above items were marked "NOT OK," describe the problem and suggest appropriate repairs.

3. Using a service manual or other information source, locate a procedure for removing the vehicle's upper control arm. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, remove the vehicle's upper control arm. Record observations.

(**NOTE:** Mark the position of the control arm. Note the position of alignment shims when applicable.)

(CAUTION: Follow the manufacturer's instructions carefully during removal and installation; failure to do so could result in serious personal injury.)

4. Using a service manual or other information source, locate a procedure for removing and replacing the control arm shaft and bushings. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, replace the control arm shaft and bushings. Record observations.

(**NOTE:** Do not tighten the cross shaft nuts on control arms with rubber bushings until the control arms are reinstalled and the vehicle is sitting at its normal ride height.)

5. Using a service manual or other information source, locate a procedure for reinstalling the control arm. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, reinstall the control arm.

a. Clean all mounting points on the control arm and frame before beginning installation procedures.

b. Reinstall the control arm either by aligning the marks made before removal or by installing the alignment shims in the same positions.

c. Tighten all fasteners to the specified torque.

d. Do not tighten cross shaft nuts on control arms using rubber bushings until the vehicle is at rest on the floor.

e. Lower vehicle.

f. If necessary tighten cross shaft nuts.

6. Check and reset all alignment angles as necessary. See the instructor for wheel alignment procedures.

JS4-L2-UX

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING LOWER CONTROL ARMS AND BUSHINGS

Equipment:

Hand tools
Hoist
Ball joint taper breaker
Specialty tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Inspect the condition of the control arm and bushings. Complete the chart below.

   Control arm bushings OK_____ NOT OK_____

   Control arm condition OK_____ NOT OK_____

   Noise when jounced OK_____ NOT OK_____

   If any of the above items were marked "NOT OK," describe the problem and suggest appropriate repairs.

3. Using a service manual or other information source, locate a procedure for removing the lower control arm. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, remove the lower control arm. Also inspect the condition of the ball joint seal and tapered stud. Check the tapered hole in the stering knuckle for wear. Record observations.

(**NOTE:** Mark the position of the alignment cams on vehicles that have the spring on the upper control arm.)

(CAUTION: Follow the manufacturer's instructions carefully during removal and installation; failure to do so could result in serious personal injury.)

4. Using a service manual or other information source, locate a procedure for replacing the lower control arm bushings. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, replace the lower control arm bushings. Record observations.

(**NOTE:** To prevent crushing the control arm, be sure to support the inner portion of the control arm when pressing bushings.)

5. Using a service manual or other information source, locate a procedure for reinstalling the control arm. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Following the procedure, reinstall the control arm.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

a. Clean all mounting points on the control arm and frame before beginning installation procedures.

b. Reinstall the control arm. When installing the arm on vehicles that have the spring on the upper arm, align the marks made before removal.

c. Tighten all fasteners to the specified torque.

6. Lower vehicle. Check and reset all alignment angles as necessary. See the instructor for wheel alignment procedures.

JS5-L2-UX

MODULE: STEERING AND SUSPENSION SYSTEMS

REPLACING BALL JOINTS

Equipment:

Hand tools
Hoist
Serviceable vehicle
Ball joint taper breaker
Specialty tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Check the condition of the ball joints. Refer to JS2-L1-UIX for this procedure. Record observations.

3. Using a service manual or other information source, locate a procedure for removing the ball joint. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, remove the ball joint.
Record observations.

4. Thoroughly clean and carefully inspect the tapered hole in the steering knuckle. Clean the ball joint mounting area of the control arm. Inspect for cracking or distortion. Record observations.

5. Using a service manual or other information source, locate a procedure for installing the ball joint. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, install and lubricate the ball joint. Refer to JS3-L1-UIX for the lubrication procedure. Record observations.

6. Lower vehicle. Check and reset all alignment angles as necessary. See the instructor for wheel alignment procedures.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XI: MACPHERSON STRUT SUSPENSION SERVICE

UNIT OBJECTIVE

After completing this unit, the student should be able to identify and replace worn Macpherson strut suspension components and diagnose problems related to MacPherson strut suspensions. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1.

I. Identify the basic components of MacPherson struts (Competencies S5, S6, and T3, Parts I and II of the Unit XI Test).

II. Identify the procedures for diagnosing and inspecting MacPherson strut suspensions (Competencies S5 and T3, Parts I and II of the Unit XI Test).

III. Identify the procedures for servicing MacPherson struts (Competencies S6 and T3, Part II of the Unit XI Test).

IV. Identify the procedures for servicing modified MacPherson struts (Competencies S6 and T3, Part II of the Unit XI Test).

V. Demonstrate the ability to:

   a. Inspect, remove, and install Macpherson strut assemblies (Competencies S6 and T3, JS1-L1-UXI).

   b. Replace MacPherson strut dampeners, springs, and mounts (Competencies S6 and T3, JS2-L1-UXI).

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XI: MACPHERSON STRUT SUSPENSION SERVICE

CONTENTS OF THIS UNIT

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XI: MACPHERSON STRUT SUSPENSION SERVICE

LESSON 1: SERVICING FRONT MACPHERSON STRUT SUSPENSIONS

I. A MacPherson strut incorporates a shock absorber and a coil spring in a single unit. Usually the entire strut assembly must be removed before either the spring, the dampener, or the top strut can be removed.

II. Diagnosing and inspecting MacPherson strut suspensions

(**NOTE:** Suspension systems using MacPherson struts are diagnosed in much the same way as conventional front suspensions.)

A. Procedure for inspecting ball joints

1. MacPherson strut suspension systems use only a lower ball joint. On MacPherson struts, the looseness of a ball joint is measured in much the same way as on conventional front suspensions. The measuring procedures do, however, vary slightly from manufacturer to manufacturer.

(**NOTE:** The ball joint used with a MacPherson strut suspension system is a nonload-carrying ball joint.)

2. Instructions for measuring ball joint looseness and inspecting ball joint condition on both conventional and MacPherson strut front suspension are outlined in Unit IX of this module. Procedures for visually inspecting ball joints on MacPherson struts are the same as those for inspecting ball joints on conventional front suspensions. Always consult the appropriate service manual before inspecting ball joints.

B. Strut rods are used on most MacPherson strut front suspensions. As with conventional suspensions, strut rods help to support and control the lower control arms. Strut rods on MacPherson struts are inspected in the same manner as strut rods on conventional front suspensions.

C. Stabilizer bars used with Macpherson struts are similar to stabilizer bars used on conventional suspensions. Inspection and diagnosis procedures for stabilizer bars on MacPherson struts are the same as for inspection and diagnosis procedures for conventional front suspension stabilizer bars.

D. Although coil springs are mounted differently on MacPherson strut suspensions, the procedures for inspecting the springs are the same as for coil springs on short-long-arm suspensions. The best way to diagnose weak coil springs on a MacPherson strut suspension is to measure vehicle ride height.

E. On a MacPherson strut, the dampener serves the same purpose as a shock absorber. However, the strut dampener is enclosed in the strut tube and is, therefore, more difficult to inspect and diagnose than a conventional shock absorber. Below is a general procedure for checking strut dampeners. For more specific procedures, refer to the proper service manual for the vehicle to be serviced.

1. Jounce the vehicle. If the vehicle bounces more than twice, the dampeners are weak.

2. Jounce the vehicle again and listen for any unusual noises. Unusual noises may mean the dampener is defective.

3. As was stated above, the dampener is enclosed within the strut. Visually inspect the strut for signs of oil that may be leaking from the dampener. Repair or replace the dampener if leaks are found.

   (**NOTE:** When inspecting the strut for oil leaks, make sure that the oil is actually coming from the dampener before making any repairs. Oil on the strut may be from the engine, the power steering system, or some other source.)

F. Procedure for inspecting and diagnosing the top strut mount

1. With the weight of the vehicle resting on the floor, turn the steering wheel to the left and right.

2. Note any binding or popping in the strut assemblies as the steering wheel is turned. Binding or noise can be caused by a defective upper strut mount bearing, which prevents the strut from rotating smoothly.

3. Raise the vehicle from under the frame, allowing the suspension to hang free.

   (CAUTION: Always use the proper equipment and observe all safety rules when raising a vehicle.)

4. Place a pry bar under each front tire and pry upward while noting any excessive looseness in the upper strut mount.

5. Check the manufacturer's service manual for specifications concerning looseness in the upper mount. Some manufacturers allow a good deal of movement in the mount.

III. Servicing MacPherson struts

A. Procedures for removing MacPherson struts

1. Raise the vehicle's hood and loosen the upper strut to the body nuts. Place a mark on one of the studs and a corresponding mark on the vehicle body. These marks will serve as reference points during reassembly.

2. Hoist the vehicle under the frame, allowing the front suspension to hang free.

3. Remove the tire and wheel assembly.

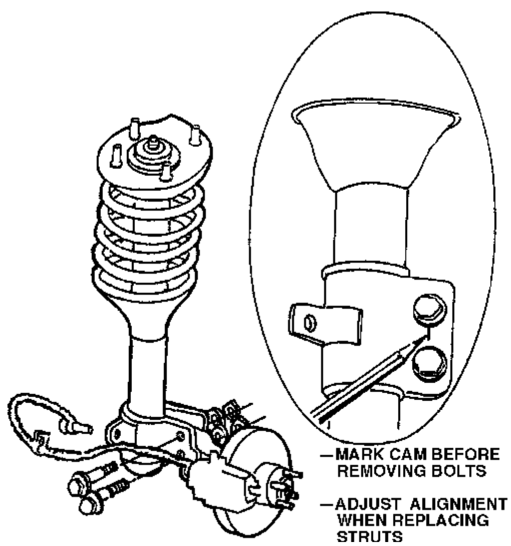
4. If necessary, remove the brake line from the mounting bracket on the strut tube. Doing so may require that a brake hose be disconnected from a brake line. The brakes will then have to be bled after assembly.

5. Either remove the lower mounting bolts holding the strut to the steering knuckle or separate the ball joint taper (depending on the way the strut is attached to the vehicle).

   (**NOTE:** If the strut is attached to the knuckle with bolts, one of the bolts may have an eccentric washer used for adjusting the alignment. If so, mark the position of the washer on the strut before removal.)

6. Finish removing the upper strut to body nuts.

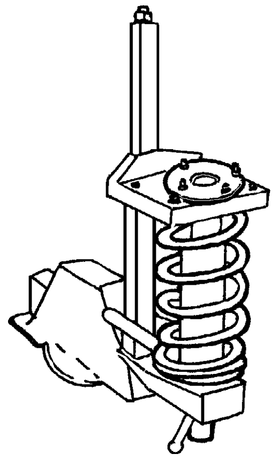
7. Remove the strut from the vehicle.



B. Procedure for disassembling the MacPherson strut

1. Once removed from the vehicle, the strut dampener, and the spring and top mount can be disassembled and serviced.

2. Before the strut can be disassembled, the spring must be compressed by using a special spring compressor. The illustration below shows a typical compressor.



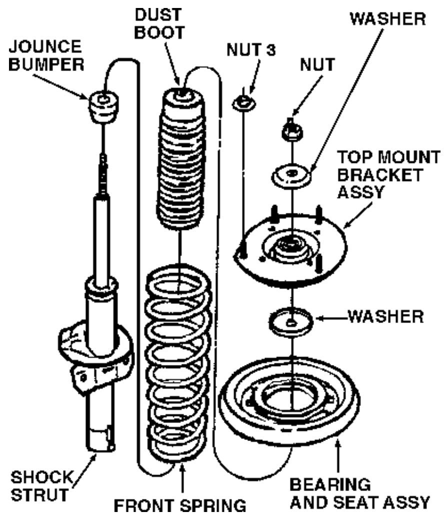
(**CAUTION**: Be sure to use the proper type of spring compressor to compress a spring. Attempting to use some other type of tool could result in serious injury to people working in the immediate area. Never disassemble a strut without first relieving the spring tension.)

3. Place the spring compressor in a vise. Mount the strut in the spring compressor according to the tool manufacturer's instructions.
   (**NOTE:** If the spring compressor is not designed to support the strut, a strut holding fixture will have to be used. Never clamp the strut tube in a vise. Doing so may crush the strut.)

4. Compress the spring and remove the retaining nut from the top of the strut.

   (**NOTE:** Never bottom the spring or the strut dampener rod.)

5. Remove the top mount assembly, the protective boot, and the jounce bumper. To aid reassembly of the strut, arrange all parts in the order that they are removed.



6. Loosen the spring compressor to relieve the tension on the coil spring.

7. Remove the strut and spring from the compressor.

C. Replacing strut dampeners

(**NOTE:** In many vehicles, the dampener cannot be replaced and is serviced along with the complete strut after the spring is removed.)

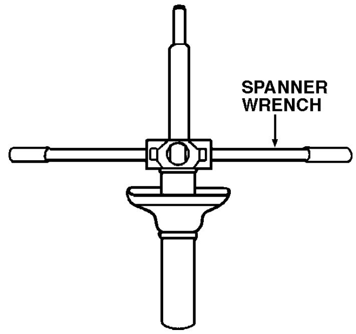
1. Strut dampeners may be either the sealed type or the repairable type.

2. Once the spring and top mount is removed, the sealed strut dampener and strut housing are serviced as a complete unit.

3. The repairable dampener is a part of a removable dampener assembly, which fits inside the existing strut housing. Below is a procedure for disassembling, servicing, and reassembling the dampener.

   a. Remove the dampener piston rod assembly, the cylinder, and the fluid either after the piston rod nut is removed from the upper end of the strut housing or after the end of the strut tube is removed.

   (**NOTE:** A pipe cutter is often used to remove the end of the strut tube. See the manufacturer's directions for the exact procedures.)



b. Thoroughly clean the housing after it is removed.

(**NOTE:** It is very important to maintain cleanliness during repair of strut dampeners.)

c. New parts should be lubricated with the specified strut dampener fluid when they are installed.

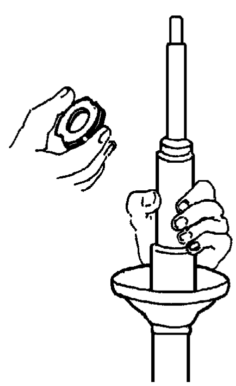
d. Fill the dampener with a specified amount of fluid. See manufacturer's specifications for the correct type and amount of fluid to use. The piston rod will need to be moved slowly to expel air as fluid is added.

e. Install the piston rod guide and o-ring.

f. Install the piston rod nut. Seal and torque the nut to specifications.

4. A sealed dampener cartridge is similar to a conventional shock absorber. The cartridge greatly simplifies installation of the dampener unit. Below is a procedure for installing the cartridge.

a. Place the strut cartridge inside of the strut tube in place of the original dampener.



b. Sometimes the manufacturer recommends that a small amount of oil be added to the strut housing to help dissipate heat.

c. Install the piston rod nut in the top of the strut housing.

D. Procedures for inspecting strut components

1. Once the spring is removed, the dampener bench is tested by using the same procedure as for testing the shock absorbers.

   (**NOTE:** Strut dampeners are more easily compressed and extended than are conventional shock absorbers.)

2. Inspection procedures for MacPherson strut coil springs are the same as inspection procedures for conventional suspension coil springs. Refer to Unit X for spring inspection procedures.

3. Procedure for inspecting the strut housing

   a. Inspect the housing for signs of physical damage.

   b. Inspect the condition of welds at the lower mounting bracket and at the lower spring mount.

4. Procedure for inspecting the top strut mount

   a. Inspect the condition of the mount. If the mount is badly deteriorated, it should be replaced.

   b. Inspect the bearing for looseness.

   c. Make sure the bearing operates smoothly.

   d. Inspect the condition of the jounce bumper.

   e. Inspect the condition of the dust boot.

E. Procedure for reassembling the strut

1. Place the strut spring compressor in a vise.

2. Compress the spring and install the strut, the upper spring seat, and the top mount.

   (**NOTE:** Make sure the spring is properly seated on the spring seat. Some manufacturers require the upper spring seat to be aligned with the lower spring seat and the lower strut mounting bracket.)

3. Install the retaining nut and tighten it to factory specifications.

F. Procedures for installing the strut

1. Install the strut in reverse order of disassembly.

2. Align the upper stud with the mark placed on the vehicle body during disassembly.

3. Align the eccentric washer with the mark on the strut to achieve approximate alignment.

4. If a brake line was disconnected, reconnect and bleed the brake system.

5. Tighten all fasteners to specified torque.

6. Check front wheel alignment and set all adjustable angles.

IV. Servicing modified MacPherson struts

A. Servicing modified MacPherson struts involves service techniques for both conventional suspensions and MacPherson strut suspensions. Once removed, the modified strut is serviced in much the same manner as a conventional strut. The spring on the MacPherson strut, however, is serviced differently from a spring on a conventional suspension.

B. Procedures for removing the spring, the ball joint, and the control arm from a modified suspension strut are much like the procedures for removing the spring, the ball joint, and the control arm from a short and long arm suspension system. Consult the proper service manual when working with these systems.

JS1-L1-UXI

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING, REMOVING, AND INSTALLING MACPHERSON STRUT ASSEMBLIES

Equipment:

Torque wrench
Hand tools
Hoist
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Place the vehicle securely on safety stands or lift it with hoist placed under the frame.

   (CAUTION: Use the proper equipment and observe the proper safety procedures when lifting the vehicle.)

3. Using a service manual or other information source, locate a procedure for inspecting a MacPherson strut assembly prior to removal. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, inspect the strut condition. Record the inspection results below.

   Dampener OK_____ NOT OK_____

   Spring condition OK_____ NOT OK_____

   Strut mount OK_____ NOT OK_____

   Strut OK_____ NOT OK_____

   Jounce bumper OK_____ NOT OK_____

   If any of the above items were marked "NOT OK," recommend appropriate repair procedures.

4. Using a service manual or other information source, locate a procedure for removing the MacPherson strut assembly. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, remove the MacPherson strut assembly.

a. If eccentric washers are used at the lower strut mount, be sure to mark their positions before removing them.

b. If any brake hoses are disconnected, plug the openings to prevent contaminants from entering the brake system.

5. Using a service manual or other information source, locate a procedure for installing the MacPherson strut assembly. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, install the MacPherson strut assembly.

a. Align marks made on eccentric washer if applicable.

b. Tighten all fasteners to the specified torque.

c. Reconnect the brake line (if it was disconnected during strut removal) and bleed the brakes.

(**NOTE:** See instructor for information on brake bleeding.)

d. Check and reset all alignment angles as necessary.

e. Lower vehicle.

(**NOTE:** See instructor for information on alignment. This procedure will be covered in a later unit.)

JS2-L1-UXI

MODULE: STEERING AND SUSPENSION SYSTEMS

REPLACING MACPHERSON STRUT DAMPENERS, SPRINGS, AND MOUNTS

Equipment:

Hand tools
MacPherson strut spring compressor
Torque wrench
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Place the vehicle securely on safety stands or lift it with a hoist placed under the frame.

   (CAUTION: Use the proper equipment and observe the proper safety precautions when lifting the vehicle.)

3. Remove the strut assembly from the vehicle, if required.

   (**NOTE:** For this procedure, refer to JS1-L1-UXI.)

4. Using a service manual or other information source, locate a procedure for disassembling the strut assembly. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, disassemble the strut assembly.

   (CAUTION: Use only spring compressors that are approved for MacPherson strut service. Make certain the compressor is securely installed on the compressed spring before the upper piston rod nut is removed.)

5. Inspect the strut components and record the results below.

Strut mount (rubber mount and bearing)	OK_____	NOT OK_____
Spring	OK_____	NOT OK_____
Dampener leakage	OK_____	NOT OK_____
Jounce bumper	OK_____	NOT OK_____

If any of the above items were marked "NOT OK," describe the problem and recommend appropriate repair procedures.

6. Bench test the dampener and record the results.

7. Using a service manual or other information source, locate a procedure for replacing the dampener cartridge. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

If the strut is equipped with a replaceable dampener cartridge, remove the strut dampener and install a cartridge. If working with a sealed strut, skip this procedure and go to item 9 below.

8. Using a service manual or other information source, locate a procedure for reassembling the strut assembly. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

   a. Replace all worn or missing parts as directed by the instructor.

   b. Be certain the spring is properly aligned and seated in the spring mounts as shown in the service manual.

9. Install the strut assembly on the vehicle if required. For this procedure, refer to JS1-L1-UXI.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XII: WHEEL BEARING AND SPINDLE SERVICE

UNIT OBJECTIVE

After completing this unit, the student should be able to service and replace wheel bearings and spindles. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1.

I. Identify the procedures for maintaining serviceable wheel bearings (Competencies S3 and T1, Part I of Unit XII Test).

II. Identify the procedures for servicing and adjusting wheel bearings (Competencies S3 and T1, Part I of the Unit XII Test).

III. Identify the procedures for inspecting and servicing nonsealed wheel bearings (Competencies S3 and T1, Part I of the Unit XII Test).

IV. Identify the procedures for adjusting nonsealed wheel bearings (Competencies S3 and T1, Part I of the Unit XII Test).

V. Identify the procedures for inspecting and servicing sealed wheel bearings (Competencies S3 and T1, Part I of the Unit XII Test).

VI. Identify the procedures for inspecting and replacing the spindle (Competency S3, Part II of the Unit XII Test).

VII. Demonstrate the ability to:

  a. Service nonsealed tapered roller wheel bearings (Competencies S3 and T1, JS1-L1-UXII).

  b. Remove and install sealed front-wheel-drive wheel bearings (Competencies S3 and T1, JS2-L1-UXII).

  c. Remove and install a wheel spindle on a long and short arm suspension (Competencies S3 and T1, JS3-L1-UXII).

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XII: WHEEL BEARING AND SPINDLE SERVICE

CONTENTS OF THIS UNIT

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XII: WHEEL BEARING AND SPINDLE SERVICE

LESSON 1: WHEEL BEARING AND SPINDLE MAINTENANCE

I. Wheel bearings are used on the front wheels of most rear-wheel-drive vehicles, on the rear wheels of many front-wheel-drive vehicles, and on the front wheels of some front-wheel-drive vehicles.

A. Bearing maintenance includes the tasks listed below.

1. Disassembling the bearings
2. Cleaning the bearings (removing all old lubricant and contaminants)
3. Inspecting the bearings for defects
4. Replacing grease seals
5. Replacing defective bearings
6. Repacking the bearings with the specified lubricant
7. Reinstalling and adjusting the bearings

II. Wheel bearing service and adjustment

A. The vehicle must be lifted when the wheel bearings are being serviced. Lift the vehicle with a jack and support the vehicle with jack stands.

(CAUTION: If the vehicle is raised with a jack for wheel bearing service, make sure that it is supported by jack stands or safety stands.)

B. Special tools are available for removing the hub cap. Wheel bearing packers can also be used to force grease into the wheel bearing. For most wheel bearing service, however, a torque wrench and common hand tools are sufficient.

C. There are many brands of quality wheel bearing lubricants on the market. Improper lubricants may break down when exposed to heat, stiffen when exposed to cold, or simply lack the lubricating capability needed for high-speed driving. Always use a high-quality wheel bearing grease. Wheel bearing grease that is identified as suitable for use in disc brake systems is usually acceptable for all applications.

D. Some wheel bearings on late-model front-wheel-drive vehicles are not serviceable. Do not attempt to lubricate nonserviceable bearings. When found defective, the entire bearing assembly must be replaced. In some cases, the entire knuckle may also have to be replaced.

E. All serviceable wheel bearings have scheduled service intervals ranging from 20,000 to 30,000 miles under normal driving conditions.

III. Inspecting and servicing nonsealed wheel bearings

(**NOTE:** Before servicing a wheel bearing, determine whether the bearing is a sealed or nonsealed bearing. Though most four-wheel-drive vehicles use sealed bearings, the bearings are individually serviceable once they are removed. Consult the proper service manual for inspecting and replacing these bearings.)

A. Procedure for inspecting nonsealed wheel bearings

1. Lift and safely support the vehicle.

2. Spin the wheel. The wheel should turn freely without binding or making any noise.

3. Grasp the wheel by the top and bottom of the tire and try to move it in and out. The wheel should move slightly (.001 to .005 inch as measured by a dial indicator on the drum or rotor).

4. If spinning the wheel and moving the tire in and out reveals no problems, then no other inspection is required. If, however, the bearings are not noisy but slightly loose, adjustment may be necessary (adjustment will be discussed below). If the bearings are noisy or excessively loose or tight, then service will be required.

B. Procedure for servicing nonsealed wheel bearings

1. Safely lift and secure the vehicle.

2. Remove the wheel.

3. Encapsulate the brake assembly and remove all asbestos dust.

(CAUTION: Do not allow brake dust to escape into the environment. Brake dust contains asbestos which can cause cancer if exhaled.)

4. Remove the brake caliper or drum.

a. If the caliper is not to be serviced at this time, the hydraulic hose may be left connected.

b. If the hydraulic hose is left connected, care should be taken to prevent the caliper from hanging on the hose.

5. Examine the hub assembly. Look for a dust cap at the center of the hub.

6. Remove the dust cap.

7. Remove the cotter pin from the spindle nut.

8. Remove the spindle nut.

    a. Carefully remove the washer and the outer wheel bearing from the center of the wheel.

    (CAUTION: Be careful not to drop the bearing.)

9. Slide the rotor off the spindle.

    (CAUTION: Do not place fingers on the friction surface of the rotor. Do not allow the rotor to drag heavily across the spindle threads.)

10. Using a brass or wooden drift, reach through the hub and tap the inner grease seal out of the hub.

11. Remove the inner wheel bearing.

12. Using a clean shop towel, wipe the grease out of the hub. Avoid getting grease on the friction surfaces of the rotor.

    (**NOTE:** If the rotor is in two pieces, work on the hubs with the friction disk removed.)

    (CAUTION: Keep all wheel bearings in sets, and return them to the spindle from which they were taken. Do not replace defective wheel bearings with used wheel bearings.)

13. Thoroughly wash the wheel bearings (and all of the other parts removed with them) in solvent. Using compressed air, blow all old grease out of the bearing. Make sure all grease is removed from the inside of the bearing. Rewash the bearings and accompanying parts.

    (CAUTION: Do not allow the bearing to spin on the finger or fingers while blowing the bearing dry; doing so may result in personal injury.)

14. Examine each bearing carefully and note any imperfections such as chips, pits, scratches, etc. Also examine bearing for discoloration, which indicates overheating. If any problems are found, replace the bearing.

    (**NOTE:** Always replace the bearing and its race if there is any doubt about its condition.)

15. Repack each bearing with fresh grease, pushing it into the larger side of the bearing assembly by hand until it is forced out of the smaller side of the bearing.

    (**NOTE:** Make sure bearings are repacked with a grease designed to withstand the high temperatures and extreme pressures to which it will be exposed.)

16. Place the equivalent of 3 or 4 table spoons of grease in the center of the hub.

17. Install the inner wheel bearing and a new grease seal.

18. Carefully slide the hub assembly onto the spindle.

19. Install the outer wheel bearing, washer, and spindle nut.

    (CAUTION: If solvent or grease gets on the drum or disc friction surfaces, the surfaces should be cleaned with an acceptable brake cleaning solvent.)

20. Adjust the bearing. Procedures for bearing adjustment are described below.

21. Reassemble the remaining brake and wheel assembly components.

IV. Adjusting nonsealed wheel bearings

(**NOTE:** Adjustment procedures for nonsealed bearings differ greatly from adjustment procedurse for sealed bearings. What is sometimes called an adjustment procedure for sealed bearings is actually a tightening procedure.)

A. Procedure for adjusting nonsealed bearings (typical rear-wheel-drive wheel bearing arrangement)

1. Safely lift and secure vehicle.

2. Remove wheel cover (hub cap).

3. Remove dust cap from wheel hub.

4. Remove cotter pin and/or nut locking device.

5. Tighten the spindle nut to manufacturer's specifications.

6. Loosen the lock nut to manufacturer's specifications.

7. Using a dial indicator, check the play in the bearings at the rotor or hub.

8. Reinstall a new cotter pin or nut holding device and then reinstall the dust cover.

9. Reassemble the remaining components of the brake and wheel assemblies.

B. Sealed bearings are not really adjusted but merely tightened. Most four-wheel-drive or front-wheel-drive vehicles have sealed bearings. If a sealed bearing makes noise or does not turn smoothly, the entire unit must be disassembled so the bearings can be evaluated and, if necessary, replaced. If sealed bearings are replaced, the new bearings must be adjusted (or tightened) according to manufacturer's specifications. Procedures for adjusting (tightening) sealed bearings vary from vehicle to vehicle. The technician must, therefore, consult the proper repair manual for the correct procedure.

(**NOTE:** On some Chrysler and foreign front-wheel-drive vehicles, use bearings that cannot be adjusted even though they are not sealed. If these bearings make noise or fail to turn smoothly, the entire unit must be disassembled so the bearings can be evaluated and packed.)

V. Inspecting and servicing sealed bearings

A. Procedure for inspecting sealed wheel bearings

1. Safely lift and secure the vehicle.

2. Spin the wheel. The wheel should turn freely without binding or making any noise.

3. Grasp the wheel by the top and bottom of the tire and try to move it in and out. The wheel should move slightly (.001 to .005 inch as measured by a caliper on the drum or rotor).

4. If spinning the wheel and moving the tire in and out reveals no problems, then no other inspection is required. If the bearings are noisy or excessively loose or tight, then the bearing will probably have to be replaced.

B. Procedures for removing and replacing sealed wheel bearings vary greatly. Refer to the proper service manual for the procedure that applies to the vehicle to be serviced.

(**NOTE:** Some front-wheel-drive vehicles may have wheel bearings that are incorporated into the knuckles. This design requires that the drive axles and bearings be removed from the knuckle. In most of these designs, the bearing must be pressed in and out of the spindle. See proper service manual for procedures regarding the replacement of sealed wheel bearings.)

(**NOTE:** Most sealed wheel bearings are non-adjustable.)

VI. Inspecting and replacing the spindle

A. Procedure for inspecting spindles

(**NOTE:** Under normal service, the spindle seldom fails. Damage from an accident or from a failed bearing is the usual cause of spindle failure. However, the technician should always inspect spindles during normal bearing service.)

1. Inspect the grease seal surface for wear or roughness.

2. Inspect the condition of the threads on the end of the spindle.

a. Rough threads make bearing adjustment difficult. Rough threads can sometimes be repaired with a thread chaser.

b. If the threads are badly damaged or stripped, the spindle should be replaced.

3. Inspect the surfaces on which the inner bearing cones rest.

   a. The surface should have no burrs or roughness. Minor nicks may be dressed down with a file.
   b. If major damage is found, the spindle should be replaced. Major damage may prevent the bearing from running true.

   c. The inner cones should slide smoothly over the spindle and yet have a snug fit. If cones are known to be good but still fit loosely, the spindle must be replaced.

B. Procedure for removing the spindle (a spindle that is integral with the steering knuckle)

(**NOTE:** The below procedure is general in nature. Refer to the proper service manual for the precise procedure for the vehicle to be serviced.)

1. Safely raise and support the vehicle under its frame.

   a. If the spring is on the upper control arm, place a suitable spacer (such as a block of wood) between the upper control arm and the frame before raising the vehicle.

   b. If the spring is on the lower control arm, place a floor jack under the lower control arm at the spring seat. Do not apply pressure to the jack before loosening the ball joint. The spring pressure will help break the ball joint tapers.

2. Remove wheel and tire assembly.

3. Remove the brake caliper and hub and rotor assembly.

4. Remove the brake rotor shield from the steering knuckle.

5. Remove thecotter pin and nut. Next, using a suitable taper breaking tool, remove the tie rod end from the knuckle.

6. Remove the cotter pin from the upper and lower ball joints.

7. Loosen the upper ball joint nut one or two turns, but do not remove the nut.

   (CAUTION: It is very important not to remove the nut before breaking the taper. The upper and lower ball joint nuts must be in place when the tapers are broken or the spring force will be unleashed.)

   a. Using a taper breaking tool, break the taper between the knuckle and the upper ball joint.

   b. It sometimes helps to rap the knuckle sharply with a hammer at the ball joint while pressure is being applied with the taper breaker.

8. Loosen the lower ball joint nut one or two turns, but do not remove the nut.

   (CAUTION: The ball joint nut should not be removed before spring pressure is applied to the spring seat. Failure to support the spring seat before removing the ball joint nut could cause serious injury to the technician.)

   a. Using a taper breaking tool, break the taper between the knuckle and lower the ball joint.

   b. As with the upper ball joint, a rap with a hammer can be helpful when removing the lower ball joint.

9. Raise the floor jack just enough to support the lower control arm.

   (CAUTION: The jack must always remain under the lower control arm while the ball joint is disconnected.)

10. Remove the upper and lower control arm nuts.

11. Remove the spindle/knuckle.

C. Procedures for replacing a spindle (a spindle that is integral with the knuckle)

1. Thoroughly clean the tapered holes in the knuckle and ball joint studs.

2. Install the knuckle in the upper and lower ball joint studs.

   a. Install and tighten the upper and lower ball joint nuts to the specified torque.

   b. Install the cotter pins in both the upper and lower ball joint studs. If necessary, tighten the nuts further to install the cotter pins; never loosen the nuts to align a cotter pin hole.

3. Install the tie rod end. Tighten the nut to the specified torque and install the cotter pin.

4. Install the brake shield and tighten the fasteners to the specified torque.

5. Clean, inspect, and repack the wheel bearings.

   a. Install a new grease seal.

   b. Replace any defective bearings.

6. Install hub and rotor.

   a. Adjust the wheel bearings according to the manufacturer's specifications.

   b. Install a new cotter pin.

7. Install the brake caliper and tighten fasteners to the specified torque.

8. Install the wheel and tire assembly. Tighten the wheel nuts to the specified torque.

9. Lower the vehicle.

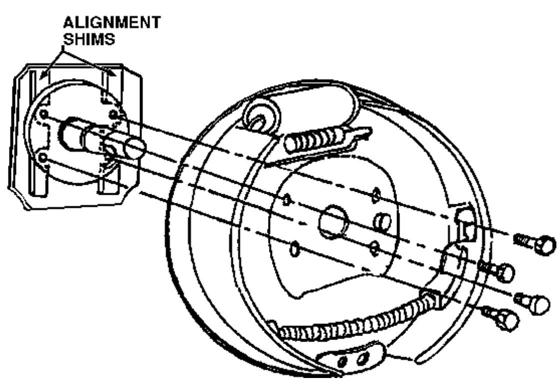
10. Apply brakes to seat pads against the rotor before moving the vehicle.

D. Procedure for removing a spindle (a spindle that is separate from the knuckle)

1. On some vehicles, particularly four-wheel-drive vehicles, the spindle is separate from the steering knuckle. The rear wheels on front-wheel-drive vehicles also have no steering knuckles on the rear but have removable spindles.

2. To remove spindles that are not integral with the steering knuckle, merely remove the bolts holding the spindle to the knuckle or axle. The bolts can be accessed after removing the wheel and tire, the brake caliper, the hub and rotor, or brake drum and backing plate.

3. On some vehicles, wheel alignment is adjusted in part by shims placed behind the spindles. If shims are used to align the spindles, note the shims' position and be sure they are reinstalled in the same manner.



JS1-L1-UXII

MODULE: STEERING AND SUSPENSION SYSTEMS

SERVICING NONSEALED TAPERED ROLLER WHEEL BEARINGS

Equipment:

Hand tools
Bearing cone drivers
Dial indicator
Seal driver
Hoist
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Place the vehicle securely on safety stands or lift it with hoist.

   (CAUTION: Be sure to use proper equipment and observe all safety rules when lifting a vehicle.)

3. Using a service manual or other information source, locate a procedure for removing and installing the wheel bearings. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, remove the front wheel bearings. Record observations. Be sure to wipe excessive grease from the bearings, hub, and spindle before cleaning the bearings.

4. Using a service manual or other information source, locate a procedure for cleaning and inspecting the wheel bearings. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, clean and inspect the bearings, hub, and spindle. Use the checklist below to note any problems.

spindle condition	OK_____	NOT OK_____
bearing cones	OK_____	NOT OK_____
bearing cages	OK_____	NOT OK_____
bearing rollers	OK_____	NOT OK_____
hub condition	OK_____	NOT OK_____

If any of the above items were marked "NOT OK," describe the problem and suggest procedures for correcting it.

(CAUTION: Do not use compressed air to spin the bearings; doing so may cause the rollers to fly out of the bearing and strike people who may be standing nearby. Allow the cones to air dry.)

5. Using a service manual or other information source, locate a procedure for repacking and adjusting the wheel bearings. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure and the procedure from number 2 of this job sheet, repack, install, and adjust the wheel bearings. Replace any damaged or missing parts as directed by the instructor. Lower the vehicle when reinstallation is completed. Record observations.

JS2-L1-UXII

MODULE: STEERING AND SUSPENSION SYSTEMS

REMOVING AND INSTALLING SEALED WHEEL BEARINGS: FRONT-WHEEL-DRIVE VEHICLES

Equipment:

Hand tools
Hoist
Special tools as needed
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet

2. Place the vehicle securely on safety stands or lift it with hoist.

   (CAUTION: Be sure to use proper equipment and observe all safety rules when lifting a vehicle.)

3. Using a service manual or other information source, locate a procedure for removing the wheel bearing. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, remove the wheel bearing. Record observations

4. Clean and inspect the steering knuckle. Record any defects found and suggest procedures to correct them.

5. Using a service manual or other information source, locate a procedure for installing the wheel bearing. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, install the wheel bearing. Tighten all fasteners to the specified torque and lower the vehicle when installation is complete.

JS3-L1-UXII

MODULE: STEERING AND SUSPENSION SYSTEMS

REMOVING AND INSTALLING A WHEEL SPINDLE ON LONG AND SHORT ARM SUSPENSIONS

Equipment:

Hand tools
Hoist
Floor jack
Ball joint taper breaker
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Place the vehicle securely on safety stands or lift it with a hoist placed under the frame.

   (CAUTION: Be sure to use proper equipment and observe all safety rules when lifting a vehicle.)

3. Using a service manual or other information source, locate a procedure for removing a wheel spindle. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, remove the wheel spindle. Record observations.

   (CAUTION: Retain the coil spring by placing a floor jack under the lower control arm. Keep the jack under the lower control arm at all times.)

4. Using a service manual or other information source, locate a procedure for installing a wheel spindle. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, install the wheel spindle. Tighten all fasteners to specified torque and lower the vehicle when reinstallation is completed. Record observations.

(**NOTE:** Be sure to inspect and repack wheel bearings before installing the spindle. Refer to JS1-L1-UXII for this procedure.)

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XIII: THE DESIGN AND OPERATING PRINCIPLES OF THE REAR SUSPENSION SYSTEM

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the components and operating principles of various types of rear suspension systems and diagnose and replace worn rear suspension components. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the basic characteristics of rear suspension systems (Competency T1, Part I of the Unit XIII Test).

II. Identify the basic characteristics of leaf spring rear suspension systems (Competency T1, Part I of the Unit XIII Test).

III. Identify the basic characteristics of rear-wheel-drive coil spring rear suspension systems (Competency T1, Part I of the Unit XIII Test).

IV. Identify the basic characteristics of trailing arm rear suspension systems (Competency T1, Part I of the Unit XIII Test).

V. Identify the basic characteristics of semi-independent rear suspension systems (Competency T1, Part I of the Unit XIII Test).

VI. Identify the basic characteristics of the MacPherson strut rear suspension systems (Competency T1, Part I of the Unit XIII Test).

Lesson 2.

I. Identify the procedures for inspecting and replacing leaf springs (Competency T2, Part II of the Unit XIII Test).

II. Identify the procedures for inspecting and replacing coil springs (Competency T1, Part I of the Unit XIII Test).

III. Identify the procedures for inspecting and replacing rear suspension control arms (Competency T4, Part III of the Unit XIII Test).

IV. Identify the procedures for replacing rear shock absorbers (Competency T2, Part II of the Unit XIII Test).

V. Demonstrate the ability to:

   a. Inspect and replace leaf springs (Competency T2, JS1-L2-UXIII).

   b. Inspect and replace rear coil springs (Competency T1, JS2-L2-UXIII).

   c. Inspect and replace rear suspension control arms and bushings (Competency T4, JS3-L2-UXIII).

   d. Inspect and replace rear suspension shock absorbers (Competency T2, JS4-L2-UXIII).

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XIII: THE DESIGN AND OPERATING PRINCIPLES OF THE REAR SUSPENSION SYSTEM

CONTENTS OF THIS UNIT

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XIII: THE DESIGN AND OPERATING PRINCIPLES OF THE REAR SUSPENSION SYSTEM

LESSON 1: REAR SUSPENSION SYSTEM DESIGN

I. Rear suspension systems use many of the same components as front suspension systems. There are several different types of rear suspension designs, all of which provide a stable ride.

II. Leaf spring rear suspensions

  A. Rear-wheel-drive leaf spring suspension

    1. Rear-wheel-drive leaf spring suspensions are equipped with single or multi-leaf springs at each end of the rear axle. These springs are normally attached to the vehicle at the three points listed below.

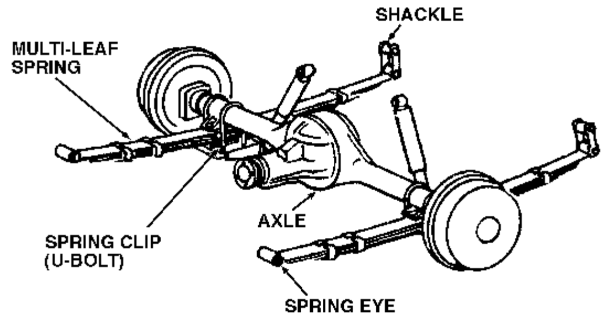
      a. The front of the spring connects to a spring hanger on the vehicle frame. The attachment is made via a rubber bushing in the spring eye.

      b. The middle of the spring is attached to the axle via U-bolts.

      c. The rear of the spring is attached to the vehicle frame by a shackle, which allows the spring to change length as the wheels roll over rough spots in the road surface.

    2. Rear-wheel-drive leaf spring suspensions normally use no control arms. The springs maintain the position of the axle assembly.

    3. In order to dampen spring movement, rear-wheel-drive leaf spring suspensions have shock absorbers mounted between the axle housing and the vehicle frame at each wheel.



Courtesy of Moog Automotive, Inc.

4. Some rear-wheel-drive leaf spring suspensions are equipped with a stabilizer bar. The front stabilizer bar enhances vehicle stability during cornering.

B. Front-wheel-drive rear leaf spring suspensions

1. Some front-wheel-drive vehicles use a solid axle rear leaf spring suspension. (A solid rear axle incorporates a bar or tube between the two rear wheels.) Spring connections on these front suspensions are made in much the same way as on rear drive leaf spring suspensions.

2. On front-wheel-drive rear leaf spring suspensions, wheel spindles bolt to each end of the axle. Shock absorbers are mounted from the axle to the vehicle frame to dampen spring movement.

III. Rear-wheel-drive coil spring rear suspensions

A. The rear-wheel-drive coil spring suspension is more complicated than the leaf spring rear suspension. The rear-wheel-drive coil spring suspension requires additional components to maintain axle positioning.

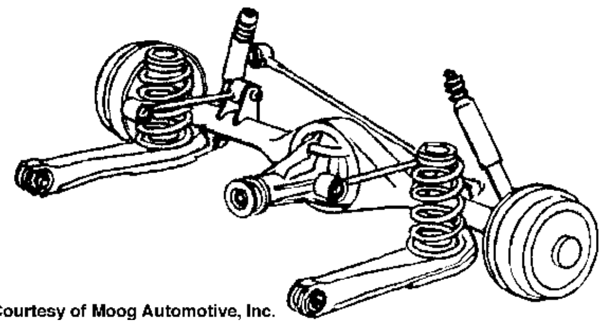
B. The typical rear-wheel-drive coil spring suspension uses a coil spring placed between the lower spring pads (which are welded to each end of the axle housing) and the upper spring pads (which are integral with the vehicle frame).

C. The rear-wheel-drive coil spring suspension uses a lower control arm on each side of the vehicle to control axle movement. The forward ends of the control arm pivot up and down on the vehicle frame via rubber bushings. The rear ends of the control arms are also connected to the axle housing via rubber bushings.

D. The rear-wheel-drive coil spring suspension also uses either one or two upper control arms, which are positioned between the axle housing and the vehicle frame. Rubber mounting bushings provide noise insulation while allowing the upper arms to pivot.

E. Some rear-wheel-drive coil spring suspensions use a track bar, which is a steel bar with rubber bushings mounted on each end. The bar is mounted between the axle housing and the vehicle frame. The track bar controls vehicle lateral movement or side sway.

F. A stabilizer bar is sometimes added to control body roll during cornering. The design and operation of the stabilizer bar are similar to the bars used in front suspension systems.



Courtesy of Moog Automotive, Inc.

IV. Trailing arm rear suspensions

A. The trailing arm rear suspension is used on many front-wheel-drive vehicles. In the trailing arm suspension, an axle beam is attached to the vehicle frame by two steel trailing arms. The trailing arms are welded to the axle and connected to the frame via rubber bushings. As the wheels move up and down, the axle beam is allowed to twist a predetermined amount, therefore providing "semi-independent" suspension action.

B. In most trailing arm rear suspensions, a track bar is used to control lateral axle movement. The track bar is mounted laterally from the axle to the vehicle frame. Rubber bushings at each end of the bar allow up and down movement.

C. Coil springs are mounted on the inboard side of the trailing arms. The lower spring pads are welded to the axle. The upper spring seats are integral with the vehicle frame.

D. In order to control spring movement, shock absorbers are mounted from the axle to the vehicle frame at each wheel.

E. Wheel spindles are bolted to each end of the axle and support the wheels through wheel bearings.

V. Semi-independent rear suspensions

A. Semi-independent rear suspension is another design found on the rear wheels of some front-wheel-drive vehicles. A semi-independent rear suspension consists of two trailing arms, which are interconnected by a lateral beam.

B. The front of the trailing arms on semi-independent rear suspensions is suspended by hanger/bushing arrangements.

C. Coil suspension springs on semi-independent rear suspensions are mounted on shock absorbers in a similar fashion to MacPherson struts.

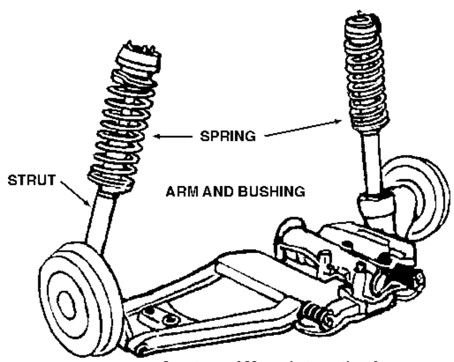
D. Wheel spindles on semi-independent rear suspensions are attached to the rear of the trailing arms.

E. Some models on semi-independent rear suspensions are equipped with a sway bar.

F. When hitting a bump, the spring will compress and the lateral beam will be forced to twist, thus allowing a limited amount of independent suspension action.

G. When the suspension rebounds, the lateral beam will return to its original position.

VI. The MacPherson strut rear suspension is similar to the MacPherson strut front suspension. A MacPherson strut unit is mounted at each rear wheel. A lower control arm is mounted between the vehicle frame and the strut at each rear wheel. The upper strut mount attaches to a reinforced vehicle body. Strut rods are used to minimize forward/rearward movement of the assemblies.



Courtesy of Moog Automotive, Inc.

AS1-L1-UXIII

MODULE: STEERING AND SUSPENSION SYSTEMS

REAR SUSPENSION SYSTEM DESIGN

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. Which components of the leaf spring rear suspension hold the axle in position?

2. In the leaf spring rear suspension, which component changes the length of the leaf spring as the vehicle travels over a rough surface?

3. On coil spring suspensions, which component is used to control axle positioning?

4. In which type of suspension are the spring and shock absorber contained in a single suspension unit?

5. Which type of rear suspension is used on most front-wheel-drive vehicles?

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XIII: THE DESIGN AND OPERATING PRINCIPLES OF THE REAR SUSPENSION SYSTEM

LESSON 2: REAR SUSPENSION SYSTEM SERVICE

(**NOTE:** Always replace suspension fasteners with fasteners of the same quality. Replacing a fastener with one of lesser quality could cause suspension failure and lead to loss of vehicle control or major repair expense. To ensure proper retention of suspension components, always tighten fasteners to the manufacturer's torque specifications.)

(**NOTE:** Never repair suspension parts by heating, quenching, straightening, or welding them. Always replace worn or damaged parts with new ones.)

I. Inspecting and replacing leaf springs

A. Procedures for visually inspecting a leaf spring suspension system (prior to removal)

1. Inspect each leaf for cracks or breaks. Broken leaves must be replaced.

   (**NOTE:** Broken leaf springs will often leave a rust deposit near the crack.)

2. Inspect the tie bolt for breakage. Broken leaves will slide out of position.

3. Inspect the condition of the inner leaves.

4. Inspect the U-bolts for tightness or breakage.

5. Make sure the rebound clips are in good condition.

6. Make sure the shackles and bushings are in good condition.

B. Procedures for removing the leaf spring

1. Raise the vehicle with a hoist or with a floor jack under the axle housing. Place safety stands under the vehicle frame. Leave hoist under the axle to relieve weight on the springs.

2. Disconnect the rear shock absorber at the axle housing.

3. Lower the axle housing, allowing the rear springs to hang free.

4. Remove U-bolts and spring retainer plate.

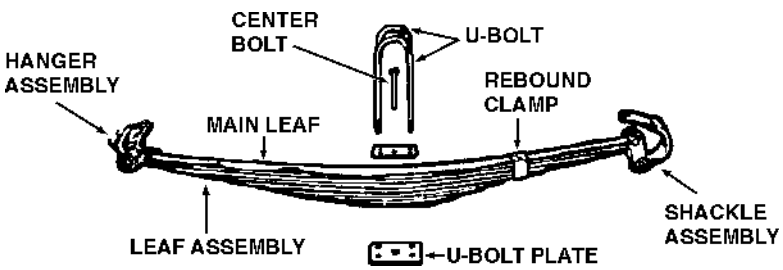
5. Raise the axle just enough to remove the weight from the spring.

6. Remove the rear shackle bolts and remove the rear shackle.

7. Remove the front hanger bolt from the front spring eye and remove the spring.

   (CAUTION: Leaf springs are very heavy. Have an assistant help to hold and lower the spring assembly from the vehicle. Serious personal injury could result from being struck by a falling spring.)

C. Inspect the leaf spring suspension system after it is removed. Use the same procedure as for inspecting the suspension prior to removal. Bushings, tie bolts, and spring leaves are more easily inspected after the spring is removed.



D. Procedure for installing the leaf spring

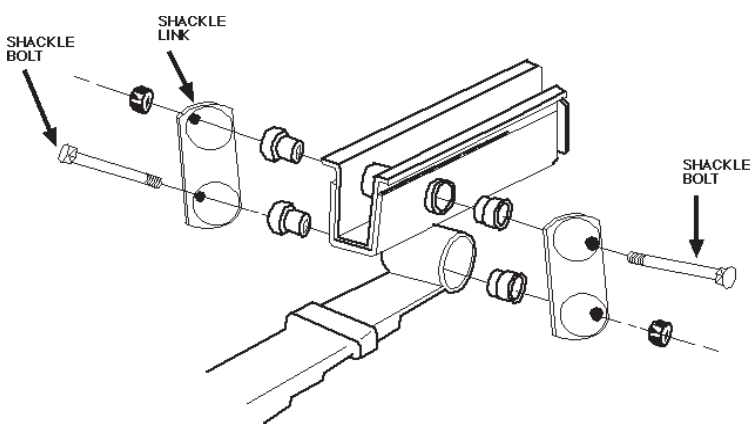
1. Place the spring under the axle and install the spring in the front hanger. Tighten fasteners only finger tight.

2. Install the rear of the spring in the shackle and tighten fasteners finger tight.

3. Lower the axle until it rests on the spring and install the U-bolts and spring plate. Tighten U-bolt nuts to specified torque.

   (**NOTE:** Make sure the center spring bolt goes in the hole in the differential housing spring plate.)

   (**NOTE:** Do not forget to install the rubber cushion between the spring and the axle housing.)



4. Connect the lower end of the shock to the axle housing plate.

5. Place safety stands under the rear axle and lower the vehicle until it is sitting at approximately normal ride height.

    a. Tighten front spring hanger bolt to specified torque.

    b. Tighten rear shackle bolts to specified torque.

    c. Remove safety stands and lower the vehicle.

E. Procedure for replacing spring bushings

1. If a spring eye bushing is found to be worn, it must be replaced. Bushing replacement is usually done while the spring is removed from the vehicle.

2. A special tool is usually required to press the old bushing out and to press the new one in. The bushings may also be pressed in and out with a shop press and suitable adapters.

II. Inspecting and replacing coil springs

A. As with front suspension coil springs, measuring the ride height gives a good indication of the condition of the spring.

(**NOTE:** Refer to Unit IX for procedures for measuring ride height.)

B. Procedure for visually inspecting coil springs

1. Look for shiny spots on the coils, which are evidence of coil spring clash (i.e. coils hitting one another during jounce). Coil spring jounce may be caused by weak springs, defective shock absorbers, or a combination of both problems.

2. Look for collapsed or broken coils.

C. Procedure for removing a rear coil spring (typical rear drive axle)

1. Raise the vehicle with a hoist or with a floor jack placed under the axle housing. Place safety stands under the frame and place the weight of the vehicle on the safety stands. Do not lower the hoist or jack all the way at this time.

    (**NOTE:** On some vehicles, the brake line between the frame and axle housing will have to be disconnected to allow enough movement of the axle housing to remove the springs.)

2. Disconnect the lower end of the shock absorbers at the axle housing.

3. Lower the hoist or floor jack and remove the springs and rubber insulators.

    (CAUTION: Do not get under the axle assembly as it is lowered.)

(CAUTION: When the jack is lowered, the springs may fall. Be prepared to secure the springs.)

D. Procedure for installing the springs

1. Inspect the condition of the insulators. If they are worn or deteriorated, replace them.

2. Clean the spring seats and remove any dirt or gravel.

3. Tape insulators to the springs to hold them in place, if necessary.

4. Place the springs between the spring seats. The springs should rest on the lower seat.

5. Raise the axle and reconnect the lower shock absorber mountings.

6. Tighten all fasteners to the specified torque.
(**NOTE:** If the brake line was disconnected, then reconnect the brake line and bleed the brake system.)

III. Inspecting and replacing rear suspension control arms

A. Procedure for inspecting the control arm

1. Inspect the arm for bent or broken lower and upper control arms and track bars.

2. Inspect bushings for deterioration and wear. Bolts should be centered in the bushings.

B. Removing and installing the lower control arm

(**NOTE:** If both control arms are to be replaced, remove only one arm at a time to prevent the axle from moving sideways or rolling.)

1. Procedure for removing the lower control arm

   a. Raise the vehicle and support it with a hoist or with safety stands placed under the axle housing.

   b. Remove the rear arm to the axle housing bracket bolt.

   c. Remove the front arm to the bracket bolts and remove the lower control arm.

2. Procedure for installing the lower control arm

   a. To install the lower control arm, merely reverse the removal procedure.

   b. Tighten all fasteners to the specified torque.

C. Removing and installing the upper control arm

(**NOTE:** If both control arms are to be replaced, remove only one arm at a time to prevent the axle from moving sideways or rolling.)

1. Procedure for removing the upper control arm (rear-wheel-drive axle)

   a. Raise the vehicle and support it with safety stands placed under the axle housing.

   b. Place a support under the differential pinion nose.

   c. Remove the front and rear arm attaching bolts and then remove the arm.

2. Procedure for installing the upper control arm (rear-wheel-drive axle)

   a. To install the upper control arm, merely reverse the removal procedure.

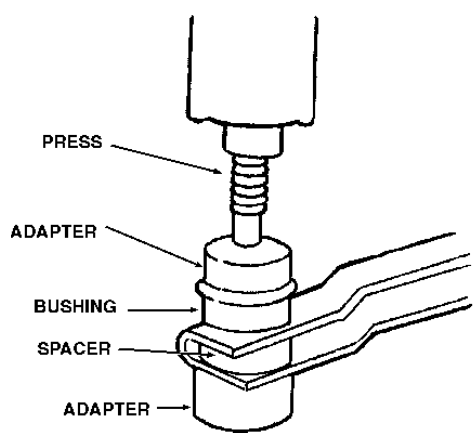
   b. Tighten all fasteners to the specified torque.

D. Control arm bushing replacement

1. The bushings in many control arms may be replaced while the arm is removed from the vehicle.

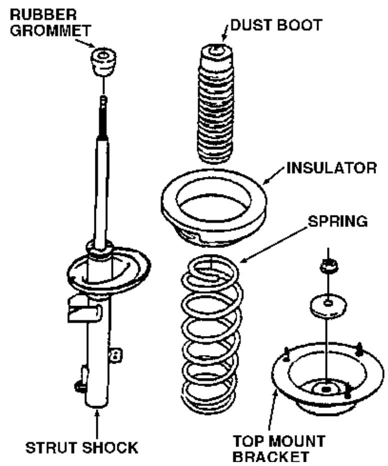
   (**NOTE:** Some bushings cannot be serviced. If nonserviceable bushings are defective, the entire control arm must be replaced.)

2. Using a press and suitable adapters, press out the bushing. Be certain to support the inner portion of the arm to prevent it from being crushed.



3. In some suspension systems, the bushings are located on the axle end of the upper arm. The bushings are pressed into a flange on the axle housing instead of the arm.

(**NOTE:** Rear suspension Macpherson struts are serviced in much the same way as front suspension Macpherson struts. Strut service is covered in Unit XI of this section. When working with a rear MacPherson strut suspension system, consult the appropriate service manual for the specific procedures.)



IV. Replacing rear shock absorbers

A. Raise the vehicle and support it under the axle housing.

(CAUTION: Failure to support the vehicle weight by the axle housing can result in serious injury when the shock is removed and the axle housing drops 4" to 7".)

B. Disconnect the upper shock absorber mounting. On some vehicles, the upper shock absorber mounting is accessed from the inside of the luggage or passenger compartment. Consult the appropriate service manual when removing shock absorbers.

C. Disconnect the lower shock absorber mounting and remove the shock absorber.

(CAUTION: If working with gas-charged shocks, do not apply heat or flame to the shock absorber tube during disassembly.)

(**NOTE:** Once gas-charged shocks are disconnected, they will expand rapidly.)

D. Install the shock absorber in reverse order of disassembly.

1. Bleed air from the shock before installing. Refer to Unit X for this procedure.

2. Tighten all fasteners to specified torque.

E. Procedures for testing rear shock absorbers are the same as for front shock absorbers. Refer to Unit X for the correct procedures.

JS1-L2-UXIII

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING LEAF SPRINGS

Equipment:

Hand tools
Hoist
Safety stands
Special tools as needed
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Place the vehicle securely on safety stands or lift it with a hoist.

   (CAUTION: Be sure to use the proper equipment and observe all related safety rules when lifting the vehicle.)

3. Using a service manual or other information source, locate a procedure for visually inspecting the spring, hangers, shackles, U-bolts, tie bolt, and interleaves. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, visually inspect the leaf spring. Record the results on the checklist below. Refer to item 4 of AS1-L2-UXIII.

   Spring leaves OK_____ NOT OK_____

   Tie bolt OK_____ NOT OK_____

   Interleaves OK_____ NOT OK_____

   Rebound clips OK_____ NOT OK______

   Shackles/bushings OK_____ NOT OK______

If any of the above items were marked "NOT OK," describe the problem and recommend repair procedures.

4. Using a service manual or other information source, locate a procedure for removing the leaf spring. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the procedure, remove the leaf spring. Record observations.

   (CAUTION: Leaf springs are very heavy. Have an assistant help to hold and lower the spring assembly from the vehicle. Serious personal injury could result from being struck by a falling spring.)

5. Following the procedure developed in item 3 of this job sheet, inspect the spring components. In the space below, record any problems found in the spring components and suggest procedures for repair.

6. Using a service manual or other information source, locate a procedure for replacing the spring eye bushing. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the procedure, replace the spring eye bushing. Record observations.

7. Using a service manual or other information source, locate a procedure for installing a leaf spring. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the procedure, install the leaf spring. Record observations.

JS2-L2-UXIII

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING REAR COIL SPRINGS AND INSULATORS

Equipment:

Hand tools
Hoist
Safety stands
Special tools as needed
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Place the vehicle securely on safety stands or lift it with a hoist.

   (CAUTION: Be sure to use the proper equipment and observe all related safety rules when lifting the vehicle.)

3. Visually inspect the coil spring. Record any problems found during the inspection (such as broken or collapsed coils or evidence of coil clash) in the space below.

4. Using a service manual or other information source, locate a procedure for removing the rear coil spring from the vehicle. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, remove the rear coil spring. Record observations.

(CAUTION: Be sure to follow manufacturer's instructions carefully during removal and installation of the rear coil spring. Failure to do so could result in serious personal injury.)

5. Inspect the rear coil spring components. Use the checklist below to note any damage.

Control arms	OK_____	NOT OK_____
Disconnected control arm bushings and bolts (if applicable)	OK_____	NOT OK_____
Shock absorber	OK_____	NOT OK_____
Disconnected stabilizer bushings	OK_____	NOT OK_____

If any of the above items were marked "NOT OK," describe the problem and recommend repair procedures.

6. Using a service manual or other information source, locate a procedure for installing the coil

spring. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, install the coil spring.

a. Clean spring mounting pads before installation.

b. Be sure to reinstall any rubber insulators before installing the spring.

c. Tighten all fasteners to specified torque.

d. Lower the vehicle.

JS3-L2-UXIII

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING REAR SUSPENSION CONTROL ARMS AND BUSHINGS

Equipment:

Hand tools
Hoist
Special tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Place the vehicle securely on safety stands or lift it with a hoist.

   (CAUTION: Be sure to use the proper equipment and observe all related safety rules when lifting the vehicle.)

3. Using a service manual or other information source, locate a procedure for removing the control arm. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, remove the rear suspension control arm. Record observations.

4. Using a service manual or other information source, locate a procedure for visually inspecting the control arm and bushings. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, inspect the control arm and bushings. Record observations.

5. Using a service manual or other information source, locate a procedure for removing and replacing the control arm bushings.. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, replace the control arm bushings. Record observations.

6. Using a service manual or other information source, locate a procedure for installing the control arm. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the procedure, install the control arm. Lower the vehicle when installation is complete. Record observations.

JS4-L2-UXIII

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING REAR SUSPENSION SHOCK ABSORBERS

Equipment:

Hoist
Hand tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Place the vehicle securely on safety stands or lift it with a hoist. Support the vehicle under the rear axle.

   (**NOTE:** It is important to support the axle during shock removal to prevent the axle from dropping down and damaging the brake line or causing injury.)

   (CAUTION: Be sure to use the proper equipment and observe all related safety rules when lifting the vehicle.)

3. Carefully inspect the shock absorbers for the following.

Secureness of mounting	OK_____	NOT OK_____
Condition of rubber bushings	OK_____	NOT OK_____
Excessive fluid leakage	OK_____	NOT OK_____
Condition of piston rod and tube	OK_____	NOT OK_____

   If any of the above items were marked "NOT OK," describe the problem and recommend repair procedures.

4. Following the procedure outlined below, remove the shock absorber.

   (**NOTE:** Do not grasp the piston rod with a wrench or pliers. Use the flats provided at the end of the piston rod.)

a. Secure the piston rod to keep it from turning. Remove the upper shock absorber retaining nut, washer, and rubber bushing.

b. Remove the bolts or nut holding the lower end of the shock absorber to the axle and remove the shock absorber.

5. Inspect the shock absorber by fully extending and compressing the piston rod several times. Complete the checklist below.

(**NOTE:** Extreme force is required to compress a gas-charged shock; therefore, this inspection procedure may be difficult to perform on a gas-charged shock.)

Is action rough?	YES_____	NO_____
Does the shock make any unusual noise?	YES_____	NO_____
Does the shock exhibit resistance to movement in both directions?	YES_____	NO_____
Does the shock expand when released from a compressed position (gas-charged only)	YES_____	NO_____

If any of the above items were marked "YES," describe the problem and recommend repair procedures.

6. Hold the removed shock in an upright position and extend it fully. Then turn it over and compress it fully. Repeat this action three times to expel any air trapped in the hydraulic cylinder.

7. Repeat step 6 and record the results below.

8. Following the procedure outlined below, install the shock absorber.

   a. In the space below, determine and record any torque specifications related to installing the shock absorber.

      (**HINT:** Use an appropriate service manual.)

   b. Hold the removed shock in an upright position and extend it fully. Then turn it over and compress it fully. Repeat this action at least three times to expel any air trapped in the hydraulic cylinder.

   c. Fully extend the shock absorber and install the lower mounting washer and grommet (if used) on the piston rod.

   d. Insert the shock through the upper mounting hole.

   e. Install the upper mounting grommet and washer; then install and tighten the retaining nut to the specified torque.

   f. Install and tighten the bolts or nut retaining the lower end of the shock to the specified torque.

   g. Lower the vehicle.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XIV: AIR ADJUSTABLE SHOCK ABSORBERS AND ELECTRONIC SUSPENSION CONTROLS

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose and replace air shocks and electronic suspension control components. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the characteristics of the design of the air adjustable shock absorber (Competency T1, Part I of the Unit XIV Test).

II. Identify the characteristics and operating principles of electronic level control systems (Competency T1, Part I of the Unit XIV Test).

III. Identify the characteristics and operating principles of electronic air suspension systems (Competency T1, Part I of the Unit XIV Test).

Lesson 2.

I. Identify the procedures for inspecting air adjustable shock absorbers (Competency T2, Part II of the Unit XIV Test).

II. Identify the procedures for replacing air adjustable shock absorbers (Competency T2, Part II of the Unit XIV Test).

III. Identify the procedures for repairing air lines (Competency T2, Part II of the Unit XIV Test).

IV. Identify the procedures for diagnosing electronic level control components (Competency T1, Part I of the Unit XIV Test).

V. Identify the procedures for repairing and replacing electronic level control components (Competency T1, Part I of the Unit XIV Test).

VI. Demonstrate the ability to:

a. Inspect and replace air adjustable shock absorbers (Competency T2, JS1-L2-UXIV).

b. Test electronic level control performance (Competency T1, JS2-L2-UXIV).

c. Leak test an electronic level control system (Competency T1, JS3-L2-UXIV).

d. Remove and install an electronic level control compressor assembly (Competency T1, JS4-L2-UXIV).

e. Test an electronic level control height sensor (Competency T1, JS5-L2-UXIV).

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XIV: AIR ADJUSTABLE SHOCK ABSORBERS AND ELECTRONIC SUSPENSION CONTROLS

CONTENTS OF THE UNIT

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XIV: AIR ADJUSTABLE SHOCK ABSORBERS AND ELECTRONIC SUSPENSION CONTROLS

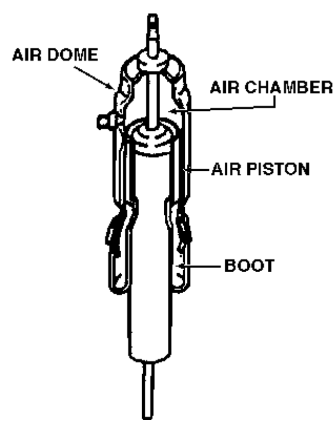
LESSON 1: DESIGN AND OPERATION OF AIR ADJUSTABLE SHOCK ABSORBERS AND ELECTRONIC SUSPENSION CONTROL SYSTEMS

I. Design of the air adjustable shock absorber

A. Air adjustable shock absorbers are basically conventional rear shock absorbers that are enclosed in air chambers. Some vehicles come equipped with air adjustable shocks; air adjustable shocks can also be added to a vehicle after manufacture.

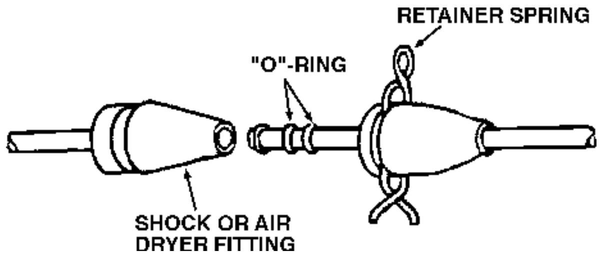
B. A pliable nylon-reinforced neoprene rubber boot is used to seal the shock absorber dust tube to the shock absorber reservoir tube. When the driver wishes to adjust vehicle ride height (to allow for a heavy load, for example), he or she activates an electrical switch which increases or reduces air pressure in the shock absorber air chamber. The increase or reduction in air pressure forces the shock to extend or retract, thus raising or lowering the vehicle ride height.

(CAUTION: Always connect air shocks in parallel with a common air valve. This prevents the failure of only one shock and reduces the risk of a serious accident.)



C. Plastic lines connect the two shock absorbers to an air valve mounted at the rear of the vehicle.

1. Brass fittings or rubber o-rings and snap lock connectors are used to connect the plastic line to the shocks and the control valve. The control valve is a Schraeder valve, similar to those used as tire valve stems.



2. A minimum air pressure of about 15 psi should be maintained at all times to reduce rubber boot friction and assure long shock life. Minimum air pressure varies, depending on the shock manufacturer.

3. Normally air pressure applied to the air shocks should not exceed 90 psi. Pressure limits vary, depending on the shock manufacturer.

4. Pressure is measured with a normal tire pressure gauge capable of registering the maximum pressure that the shocks can withstand.

D. If the system develops a leak and loses air pressure, the shock absorber will continue to function as a conventional shock absorber.

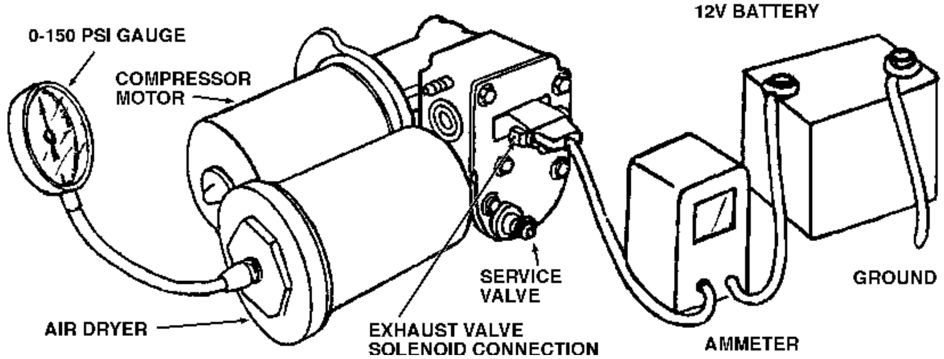
II. Electronic level control systems

A. Electronic level control systems automatically adjust vehicle ride height according to vehicle weight by increasing or reducing pressure in the air chambers of the adjustable air shocks.

B. Components of the electronic level control system

1. Electronic level control systems include air adjustable shock absorbers, air lines, air compressor, and sensor valve.

2. Electronic level control systems usually use a positive displacement, single-piston air compressor driven by a permanent magnet 12-volt direct current motor. The compressor is normally mounted in the engine compartment of the vehicle. When the ignition is turned on and weight is added to the vehicle, the compressor will run, supplying compressed air to the shocks. An exhaust solenoid is attached to the compressor and receives current from the battery's positive terminal. If weight is removed from the vehicle, the solenoid is activated and allows the system to exhaust air in order to readjust vehicle height.



3. Electronic level control systems use an air dryer, consisting of a dry chemical (desiccant) that absorbs moisture from the atmosphere before it is delivered to the air shocks. The air dryer also returns the moisture to the atmosphere when the air is exhausted. The dryer contains a valving arrangement that maintains a minimum air pressure in the air shocks at all times.

4. As mentioned above, electronic level control systems include an exhaust solenoid. When activated by the height sensor, the solenoid exhausts air from the system. The exhaust solenoid also holds compressor pressure output to a predetermined limit.

5. A pressure-limiting valve controls the maximum line pressure to achieve the smoothest ride. The limiting valve is not included on all electronic level control systems.

6. When activated by the height sensor, the relay completes the electrical circuit to the compressor motor.

7. Most electronic level control systems use an electric height sensor, which is mounted on a frame crossmember. The height sensor is connected to the rear axle by a moveable arm. When vehicle height changes, the height sensor activates the relay, which turns the compressor on and off. (As indicated above, the action of the compressor provides pressure to the shock air chamber, thus extending the shock and raising the vehicle.) The height sensor also controls the operation of the exhaust solenoid.

   (**NOTE:** In order to prevent the unnecessary activation of the compressor during normal ride motion, the sensor has a built-in delay of 10 to 28 seconds. In order to protect the compressor during a major air leak, the sensor automatically limits the compressor to a maximum running time of five minutes.)

III. Electronic air suspension systems

A. Electronic air suspension systems are currently used only on a few luxury automobiles. Listed below are features and components that electronic air suspension systems and electronic level control systems have in common.

1. Both systems use a single-cylinder 12-volt compressor.

2. Both systems use a dryer to remove moisture from system air.

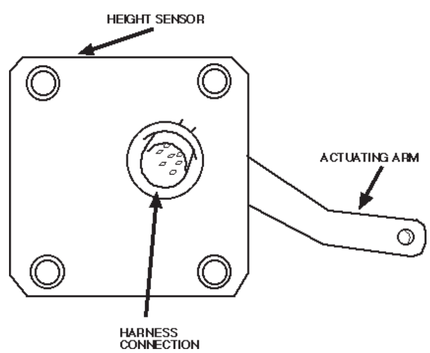
3. Both systems use height sensors to determine vehicle ride height.

B. Though in many ways similar to the electronic level control system, the electronic air system is far more sophisticated. Listed below are various technologically advanced features of the electronic air suspension.

1. At both the front and rear wheels, electronic air suspensions use air springs made of rubber and plastic instead of conventional coil springs. The rubber and plastic air springs are mounted much like conventional coil springs.

2. Electronic air suspensions are equipped with front and rear shocks/struts that are similar to those used in conventional suspensions.

3. In electronic air suspensions, height sensors mounted at each front wheel and at the rear axle relay electronic signals to a control module (a computer). The control module maintains proper vehicle ride height based on these signals.



C. Operation of the electronic air suspension system

1. When weight is added to a vehicle, the vehicle body will settle. As settling occurs, the height sensors are moved and, as a result, send signals to the control module (a computer). The control module then activates the air compressor (through a relay) and opens solenoid valves on the air springs. This causes the suspension to rise and the height sensors to move. When the predetermined height is reached, the control module closes the solenoid valves and turns off the compressor.

2. When weight is removed from the vehicle, the body will rise. As the body rises, the height sensors are moved. Upon moving, the sensors send signals to the control module. The control module opens the compressor vent solenoid and the air spring solenoid valves. When the predetermined height is reached, the module closes the compressor vent solenoid and the air spring solenoid valves.

D. Electronic suspension

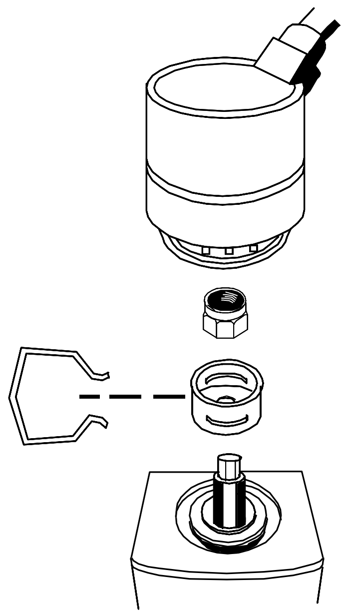
1. Many auto manufacturers offer some type of electronic suspension system: some are very complicated and even include the use of sonar that bounces sound waves off the road to sense bumps or irregularities.

2. The GM electronic suspension selective ride control (SRC) consists of four adjustable gas charged shocks. Actuator motors are mounted on top of each shock and are operated by a suspension computer. This system adjusts the shock damping rate only—the ride never changes. Inputs to the computer include a three position driver selectable switch, the vehicle speed sensor, and signals from each actuator’s Hall Effect position sensor. Based on the car’s speed and location of the switch, the computer powers the actuator motors so that they rotate a certain number of degrees.

3. Inside the conventional looking shock shaft is a thin rod, called the damping rod. It extends from the top of the shaft down to the piston. On top of the damping rod is a gear on the rod that enables the actuator to rotate up to 160 degrees inside the larger shaft; as it turns, it gradually closes off the bypass orifice. The smaller the orifice becomes, the stiffer the shock.

4. SRC vehicles are equipped with a service ride control warning light. When the light is on, the system is in a fail-safe mode and the computer has locked all actuators at the 60 degree position. The SRC warning light can be used to display 13 possible trouble codes that might be stored in the computer. There are two problems that will not set codes in the SRC system: a leaking or worn out shock and system voltage out of the 10 to 16 volt range.

5. Replacement of worn or damaged shocks on the SRC system is only a little more complicated than any conventional shock. However, care must be taken during shock replacement not to damage the actuator. An impact wrench should not be used to remove or install the top retaining nut as this might jam the damping rod. The actuator should not be hit during installation; press it on gently by hand and make sure there is a good mesh between the damping rod gear and actuator gear.



AS1-L1-UXIV

MODULE: STEERING AND SUSPENSION SYSTEMS

AIR SHOCK AND ELECTRONIC SUSPENSION CONTROL

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. List six major components of an electronic level control system.

2. The air dryer in an electronic level control system removes moisture from the air being delivered to what suspension component?

3. What kind of springs are used in an electronic air suspension system?

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XIV: AIR ADJUSTABLE SHOCK ABSORBERS AND ELECTRONIC SUSPENSION CONTROLS

LESSON 2: DIAGNOSING AND REPLACING AIR ADJUSTABLE SHOCK ABSORBERS AND ELECTRONIC SUSPENSION CONTROL SYSTEMS

I. Inspecting an air adjustable shock absorber

A. Procedure for visually inspecting an air adjustable shock absorber

(**NOTE:** Visually inspect the air adjustable shock absorber in the same way as a conventional shock absorber. In addition, perform the inspection procedures listed below.)

1. Visually inspect the condition of the air lines.

a. Inspect air lines for breaks or kinks.

b. Inspect lines for proper routing. Plastic lines will melt if they are too close to exhaust components.

c. Inspect the condition of air line fittings.

2. Inflate the shocks to the maximum pressure recommended by the manufacturer and inspect the condition of the rubber air boots.

(**NOTE:** Light cracking of the rubber boot does not necessarily indicate a bad boot. If boots are cut, leaking, or badly deteriorated, the shock absorber must be replaced.)

B. Procedure for inspecting air adjustable shock absorbers for air leaks

(**NOTE:** Though a system may exhibit evidence of air leaks, the source is sometimes difficult to locate.)

1. Apply a soapy water solution to the various components.

2. Inflate the system to the maximum pressure recommended by the manufacturer.

3. Raise and support the vehicle.

(CAUTION: Follow all related safety procedures when lifting a vehicle.)

4. Apply soapy water to the shock, lines, fittings, and air valve.

5. Note if the soapy water begins to bubble. Bubbling is an indication of leaks.

II. Replacing the air adjustable shock absorber

A. Procedure for removing an air adjustable shock absorber

1. Discharge all air from the system by depressing the control valve.

2. Raise the vehicle and support it under the rear axle.

(CAUTION: Failure to support the vehicle weight by the axle housing can result in serious injury when the shock is removed and the axle housing drops 4" to 7".)

3. Disconnect the air lines from the air adjustable shock absorbers.

4. Disconnect the upper shock mounting.

5. Disconnect the lower shock mounting and remove the shock.

B. Procedure for installing an air adjustable shock absorber

1. Install washers and rubber grommets on the shock. (Some shocks may not use washers or grommets.)

2. Attach the lower shock mounting and tighten it to the specified torque.

3. Attach the upper shock mounting and tighten it to the specified torque.

4. Connect the air lines. Tighten the fittings to the specified torque if applicable.

5. Inflate the shocks to the maximum pressure.

6. Using a soapy water solution, check all air line connections for leaks.

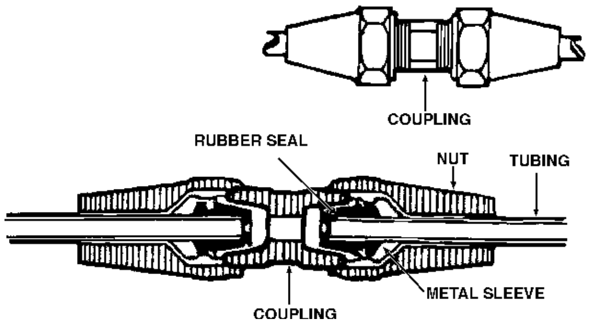
7. Adjust to desired pressure and ride height.

III. Procedures for repairing air lines

(**NOTE:** The plastic air lines are often mispositioned, causing them to tear, break, or fall against hot exhaust pipes. Repair kits can be very useful in restoring damaged lines.)

A. Detach the line and cut off the damaged portion with a razor blade or sharp knife.

B. Splice the existing tubing to the replacement tubing with a special coupling such as the one shown below.



C. Reinstall the air line.

1. Tie the tubing to the vehicle with tie straps. Route the lines in a manner that will prevent damage.

2. Activate the compressor and leak test the repaired area, using soapy water as described above.

IV. Diagnosing electronic level control components

(**NOTE:** The following procedures cover only the major components of electronic level control systems. The procedures are very general in nature. Refer to the proper service manual for complete and detailed information for the vehicle to be serviced.)

A. Procedure for testing the height sensor

1. Depending on the vehicle being serviced, either cycle the ignition on and off or turn the ignition on and shift the gear selector from park to reverse and back to park.

2. Raise and secure the vehicle. Support the rear axle at normal ride height.

3. Inspect wiring connections at the height sensor and the sensor ground.

4. Disconnect the link from the height sensor arm.

   a. Move the height sensor arm up. After a delay of 10 to 28 seconds (time varies depending on model of vehicle), the air compressor should come on, thus filling the shock absorber air boots.

   b. Once the boots start to fill, move the arm down. The compressor should stop running.

   c. After a delay of 10 to 28 seconds, the shocks should start to deflate.

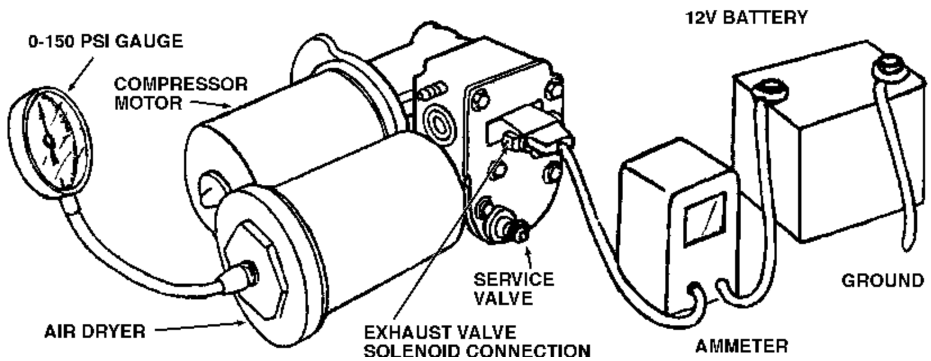
B. Procedure for testing compressor performance

(**NOTE:** The compressor may be tested either while on the car or on a work bench.)

1. Disconnect the wiring from the compressor motor and the exhaust solenoid terminals.

2. Disconnect the pressure line from the dryer and attach a 0- to 150-psi pressure gauge to the dryer fitting.

3. Connect a 12-volt power supply to the compressor with an ammeter connected in series between the power supply and the compressor.



4. Current draw should not exceed 14 amps.

5. When the gauge reaches approximately 110 psi, shut off the compressor. Note whether the pressure holds or leaks down. (Allow the pressure to stabilize).

   (**NOTE:** If the compressor is permitted to run until it reaches 120 to 150 psi, the pressure relief valve in the exhaust solenoid will open and cause the system to leak down. This will result in a false leak indication.)

6. Compare the results of step "a" and step "b" above to the manufacturer's specifications and take appropriate action.

C. Adjusting the height sensor

1. The height sensor may be adjusted to raise ride height (compressor is activated by less suspension travel) or lower ride height (compressor is activated by more suspension travel).

2. Measure the vehicle's ride height. See Unit IX of this module for the procedure.

3. Procedure for raising ride height

   a. In order to change sensor adjustment, a slotted adjustment or an adjusting screw on the actuating arm assembly must be moved.

b. On many units, ride height can be raised by loosening the lock nut that retains the metal arm to the plastic height sensor arm. The plastic actuator arm can then be slid upward, thus changing the actuator position. As the position of the actuator changes, the compressor is activated or deactivated. In this way, the air is added to shocks as needed to achieve the newly adjusted ride height.

4. Procedure for lowering ride height

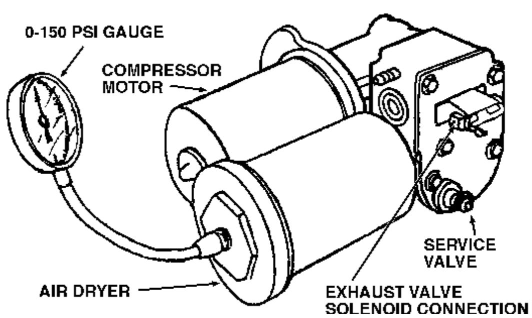
a. Loosen lock nut and move the plastic arm downward to the bottom of the slot and retighten the lock nut.

b. If height cannot be properly adjusted, check vehicle ride height. Also check to see if the height sensor being used is the proper one for the vehicle.

D. Procedure for leak testing the system

(NOTE: The leak testing procedure outlined below requires the use of a pressure gauge with a "Schraeder" valve, a shut off valve, and adapters to connect the gauge and the valve into the system being tested.)

1. Tee a pressure gauge into the system between the dryer and the air line with a shut off valve positioned on the compressor side of the gauge.



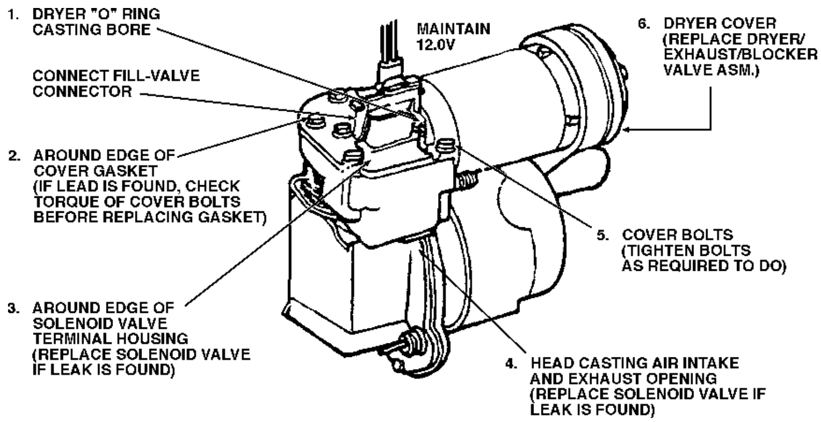
2. Open the shut off valve and apply shop air through the "Schraeder" valve until the gauge reads 100 to 120 psi.

3. If the gauge pressure starts to drop, a leak is indicated.

4. Isolate the compressor by closing the shut off valve.

5. If the gauge continues to drop when the shut off valve is closed, the leak is not in the compressor. Leak test all other components using a soapy water solution.

6. If gauge pressure stops dropping when the shut off valve is closed, the leak must be in the compressor. Apply a soapy water solution to the compressor and watch for air bubbles.



V. Repairing and replacing electronic level control components

A. Removing and reinstalling the compressor

1. Procedure for removing the compressor

a. Disconnect the electrical connectors from the exhaust solenoid and the motor terminals. Also disconnect the hose from the dryer.

b. Remove the screws retaining the compressor mounting bracket to the vehicle and remove the compressor.

c. Remove the mounting bracket fasteners and then remove the compressor from the mounting bracket.

2. Procedure for reinstalling the compressor

a. Install the compressor in reverse order of disassembly.

b. Tighten all fasteners to specified torque.

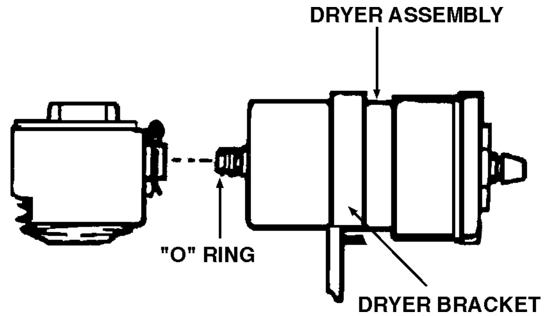
c. Lightly pressurize the system by adding air to the compressor service valve.

B. Disassembling, inspecting, and reassembling the compressor

(**NOTE:** Only a limited number of compressor parts can be serviced. The compressor should be disassembled only far enough to allow required service or replacement of parts.)

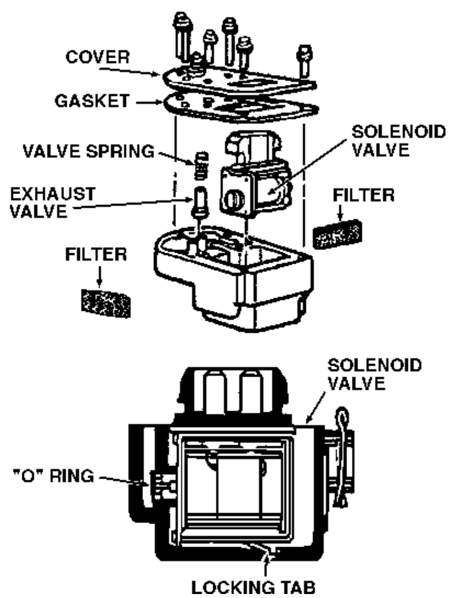
1. Procedure for disassembling the compressor

a. Remove the dryer by rotating the retainer spring 90 degrees and pulling the dryer out of the casting. Remove the o-ring from the casting if it does not come out with the dryer.



b. Remove the screws attaching the cylinder head assembly to the compressor and remove the cylinder head assembly and o-ring.

c. Remove cover screws from the head assembly. Remove the cylinder head cover and gasket, the exhaust valve and spring, and the solenoid valve and filters.



d. Remove motor case screws and pull the case and magnet assembly off the armature.

(**NOTE:** There are no serviceable parts in the compressor or motor; therefore, do not disassemble compressor or motor further. If parts within the compressor or motor are defective, the entire compressor or motor must be replaced.)

2. Procedure for visually inspecting the compressor

a. Inspect compressor assembly for wear or damage. If wear and damage are found, the compressor and motor assembly must be replaced as a unit.

b. Inspect motor for wear or damage. Like the compressor, the motor has no serviceable parts.

3. Procedure for reassembling a compressor

a. Install all compressor parts in reverse order of disassembly.

b. Make sure all defective compressor components are replaced.

c. Tighten all fasteners to manufacturer's specified torque.

C. Removing and reinstalling the height sensor

1. Procedure for removing the sensor

a. Raise and secure the vehicle.

b. Disconnect the electrical connector from the height sensor.

c. Disconnect the link from the height sensor arm.

d. Remove the screws attaching the height sensor to the frame and remove the sensor.

e. Install the sensor in reverse order of removal.

JS1-L2-UXIV

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING AIR ADJUSTABLE SHOCK ABSORBERS

Equipment:

Hand tools
Hoist
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Following the procedure outlined below, remove the shock absorber.

    a. Discharge all air from the system.

    b. Raise the vehicle and support the rear axle.

        (CAUTION: Failure to support the vehicle weight by the axle housing can result in serious injury when the shock is removed and the axle housing drops 4" to 7".)

    c. Disconnect the air line from the shock absorber.

    d. Remove the upper shock mounting.

    e. Remove the lower shock mounting and the shock absorber.

3. Inspect the condition of the plastic air lines and connectors. Any damaged or broken lines must be repaired or replaced. Describe below any repairs made to the air lines.

4. Following the procedure outlined below, install the air adjustable shock absorber.

    a. Determine and record below all torque specifications related to the installation of the shock absorber.

b. Attach the lower shock mounting and tighten it to the specified torque.

c. Attach the upper shock mounting and tighten it to the specified torque.

d. Connect the air lines.

5. Inflate the shock absorbers to the maximum specified pressure.

 a. Prepare a soapy water solution and apply it to all connections.

 b. Inspect for leaks at all connections and make repairs as necessary.

 c. Lower the vehicle.

6. Adjust shocks to desired height/pressure.

JS2-L2-UXIV

MODULE: STEERING AND SUSPENSION SYSTEMS

TESTING ELECTRONIC LEVEL CONTROL PERFORMANCE

Equipment:

Hand tools
Ammeter
Pressure gauge
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Disconnect the wiring harness at the compressor motor and the exhaust solenoid terminals.

3. Disconnect the pressure line from the dryer and attach a 0- to 150-psi pressure gauge to the dryer fitting.

4. Connect an ammeter in series between the positive battery terminal and the compressor.

5. While monitoring the ammeter reading, run the compressor. When pressure reaches 110 psi, shut off the compressor and observe the pressure gauge. Use the checklist below to record findings.

   (**NOTE:** If the compressor is permitted to run until it reaches 120 to 150 psi, the pressure relief valve in the exhaust solenoid will open and cause the system to leak down. This will result in a false leak indication.)

   Does the current draw exceed 14 amps? YES_____ NO_____

   Does the compressor fail to reach 110 psi? YES_____ NO_____

   Does pressure leak off? YES_____ NO_____

If any of the previous items were marked "YES," describe the problem and then refer to the appropriate service manual and recommend repair procedures. If all the above items were marked "NO," go to item 6 of this job sheet.

6. Reconnect the wiring and air line.

JS3-L2-UXIV

MODULE: STEERING AND SUSPENSION SYSTEMS

LEAK TESTING THE ELECTRONIC LEVEL CONTROL SYSTEM

Equipment:

Hand tools
0- to 150-psi pressure gauge
Shut off valve
Safety glasses
Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Tee the pressure gauge into the system between the dryer and the air line. Make sure the shut off valve is on the compressor side of the gauge.

3. Open the shut off valve and apply shop air through the Schraeder valve until the gauge reads 100 to 120 psi. Note the pressure gauge. Does the pressure hold steady?

   YES_____ NO_____

   If "YES" was marked, go to step 7 of this job sheet. If "NO" was marked, go to step 4 of this job sheet.

4. Isolate the compressor by closing the shut off valve. Does the pressure hold steady?

   YES_____ NO_____

   If "YES" was marked, go to step 5 of this job sheet. If "NO" was marked, go to step 6 of this job sheet.

5. Apply a soapy water solution to all components except the compressor and observe for leaks. Record observations.

6. Apply a soapy water solution to the compressor assembly and observe for leaks. Record observations.

7. Based on the results of the tests and inspections performed in this job sheet, describe the condition of the system and recommend repair procedures, if necessary.

JS4-L2-UXIV

MODULE: STEERING AND SUSPENSION SYSTEMS

REMOVING AND INSTALLING AN ELECTRONIC LEVEL CONTROL COMPRESSOR

Equipment:

Hand tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for removing and reinstalling the compressor assembly. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, remove the compressor assembly. Record observations.

3. Inspect the condition of the air line and wiring once they are disconnected from the vehicle. Record observations.

4. Following the procedure from item 2 of this job sheet, install the compressor assembly. Record observations.

5. Test compressor performance. For this procedure, refer to JS2-L2-UXIV. Record the results of the performance test.

6. Leak test the air line connection at the compressor with a soapy water solution. Record results below.

   NO LEAKS_____ LEAKS FOUND_____

   If leaks are found, they must be repaired.

JS5-L2-UXIV

MODULE: STEERING AND SUSPENSION SYSTEMS

TESTING AN ELECTRONIC LEVEL CONTROL HEIGHT SENSOR

Equipment:

Hand tools
Hoist
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Place the vehicle securely on safety stands or lift it with a hoist. Support the axle so it is as close as possible to normal ride height.

3. Using a service manual or other information source, locate a procedure for testing the operation of the height sensor. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, test the height sensor. Use the checklist below to record the test results. Lower the vehicle when the test is completed.

   Do the shock absorbers fill
   when the control arm is moved upward? YES_____ NO______

   Does the compressor stop running
   when the control arm is moved down? YES_____ NO_____

   Do the shock absorbers deflate
   when the control arm is moved downward? YES_____ NO______

   Is there a proper amount of delay
   before the shock absorber responds? YES_____ NO_____

   If any of the previous items were marked "NO," describe the problem and recommend appropriate repair procedures.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XV: WHEELS AND TIRES

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the various types of tires and wheels used on passenger cars, identify problems related to passenger car tires, and determine and make repairs. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the basic characteristics of the automobile tire (Competency U1, Part I of the Unit XV Test).

II. Identify the three basic types of passenger car tire construction (Competency U1, Part I of the Unit XV Test).

III. Identify the characteristics of tire cord body construction (Competency U1, Part I of the Unit XV Test).

IV. Identify the characteristics of tire grading systems (Competency U1, Part I of the Unit XV Test).

V. Identify the characteristics of tire load range (Competency U1, Part I of the Unit XV Test).

VI. Identify the characteristics of tire ply ratings (Competency U1, Part I of the Unit XV Test).

VII. Identify the characteristics of tire sizing (Competency U1, Part I of the Unit XV Test).

VIII. Identify the characteristics of convenience spare tires (Competency U1, Part I of the Unit XV Test).

IX. Identify the characteristics of wheel construction (Competency U1, Part I of the Unit XV Test).

Lesson 2.

I. Identify the procedures for inspecting tires (Competency U1, Part I of the Unit XV Test).

II. Identify the procedures for removing the tire and wheel assembly (Competency U4, Part II of the Unit XV Test).

III. Identify the procedures for installing the tire and wheel assembly (Competency U4, Part II of the Unit XV Test).

IV. Identify the procedures for rotating tires (Competency U4, Part II of the Unit XV Test).

V. Demonstrate the ability to:

  a. Inspect and inflate tires (Competency U1, JS1-L2-UXV).

  b. Rotate tires (Competency U4, JS2-L2-UXV).

Lesson 3.

I. Identify the procedures for dismounting tires (Competency U4, Part II of the Unit XV Test).

II. Identify the procedures for mounting tires (Competency U4, Part II of the Unit XV Test).

III. Identify the procedures for repairing tubeless tires with the patch plug and the patch methods (Competency U4, Part II of the Unit XV Test).

IV. Demonstrate the ability to:

  a. Dismount and mount tires (Competency U4, JS1-L3-UXV).

  b. Repair punctures in tubeless tires (Competency U4, JS2-L3-UXV).

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XV: WHEELS AND TIRES

CONTENTS OF THE UNIT

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XV: WHEELS AND TIRES

LESSON 1: TIRE AND WHEEL DESIGN

I. Automotive tires provide traction and absorb road shocks. Typical automotive tires must perform well on a variety of road surfaces and driving conditions. Tires must provide traction on asphalt, concrete, gravel, and dirt. Tires must also be designed to function as effectively on wet or snow-covered roads as on dry roads. Most of the tires used today are tubeless; however, some tube tires are still produced.

A. In a tubeless tire, air under pressure is retained by the tire and wheel. A soft rubber inner liner is built into the tire to prevent air from leaking through the tire fabric (plies).

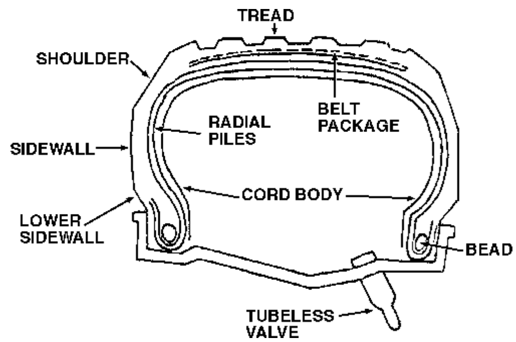
B. In tires using tubes, both the tire and an inner tube are mounted on a wheel. The tube is inflated and retains the air inside the tire. Tires with tubes are seldom used in today's cars and light trucks.

II. There are three basic types of passenger car tire construction: bias-ply, bias-belted, and radial-ply. All tire types have the following components: beads, cord body, and tread.

A. Beads are bands of strong steel wire, which are fastened to the tire plies and molded to the inner circumference of the tire. The beads hold the tire in position on the rim.

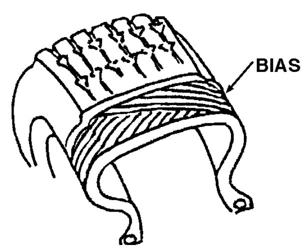
B. The cord body consists of layers of rubber-impregnated fabric (plies). These layers are molded together in rubber to form the tire. The cord body is attached to the steel bead wires. The way the plies are assembled determines the tire construction design (radial plies, bias-belted, etc.). The number of plies determines the load-carrying capacity of the tire.

C. The tread is the part of the tire that contacts the road. The tread rubber is molded directly to the cord body. Rubber is also molded to the cord body sidewalls. Varying tread designs and rubber compounds are used to comply to specific tire designs.

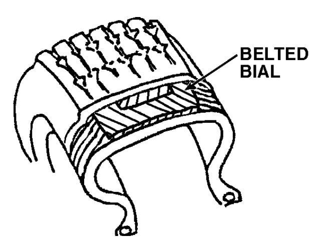


III. Tire cord body construction

A. Bias-ply tires consist of two or possibly even four or more plies placed one on top of another. The cords run in a crisscross (bias) pattern from bead to bead. Plies are constructed of rayon, nylon, polyester, etc.

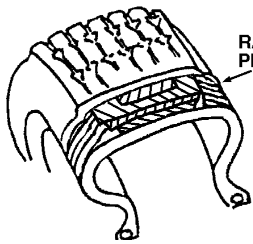


B. Bias-belted tires are constructed like bias-ply tires. However, bias-belted tires have two or more layers of tread-reinforcing plies or belts wrapped around the circumference of the tire under the tread. These "belts" do not extend to the sidewalls but rather are positioned under the tread area only. The belts are usually constructed of fiberglass, rayon, or steel. The added belts allow for better wear and handling and increased puncture resistance.



C. In radial-ply tires, the plies of the cord body run in straight lines, parallel to each other and perpendicular to the beads. The plies are at right angles to the tire tread. Two or more belts, made of either fabric or steel, are laid on top of the cord body, under the tread section. Radial-ply tires offer better traction, increased tread life, softer ride and less rolling resistance, which allows for better fuel economy. Radial-ply tires are, therefore, used on the majority of today's passenger cars.

(**NOTE:** Vehicles should not be operated with both radial- and bias-ply tires due to the different handling characteristics of the two tires.)



IV. Tire grading (uniform tire-quality grading system)

A. The National Highway Safety Administration established standards of quality for passenger tires. These standards fall into the categories of tread wear, traction, speed, and ability to dissipate heat. The tire's rating in these various categories is molded into the tire during its construction.

B. In the category of tread wear (length of tread life), each tire is assigned a grade number: 90, 100, etc. A tire with a grade of 180, for example, should wear twice as long as one with a grade of 90.

C. The letters A, B, and C are used to rate a tire's ability to provide traction during wet road conditions. A tire with an A rating offers the best traction under wet conditions while C offers minimum traction under wet conditions.

D. The letters A, B, and C are also used to indicate the tire's ability to dissipate or resist heat. A tire with a rating of A has the greatest ability to dissipate or resist heat while a tire rated C has the least ability to resist heat.

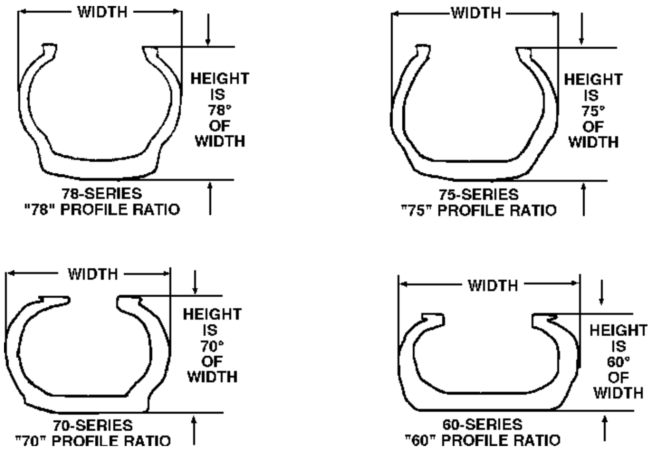
E. A tire's speed rating indicates the maximum speed at which a tire can safely operate. The letter S, H, or V is added to the tire size after the aspect ratio designation. A speed rating of "S" indicates a maximum safe operating speed of up to 112 MPH; H indicates a maximum safe operating speed of up to 130 MPH; V indicates a maximum safe operating speed of over 130 mph.

V. Load range is a term used to identify the size of a given tire, its inflation limit, and its maximum load. Again the letters A, B, and C are used. The letter C indicates a greater load-carrying capacity than the letter A.

VI. A tire's ply ratings are a general indication of its load-carrying capacity. The ply rating is molded into the tire's sidewall. The ply rating number is not necessarily the same as the number of actual plies. For example, a tire with a two-ply sidewall construction may receive a four-ply rating. The two-ply tire would receive this rating if it had a four-ply load-carrying capacity.

VII. Tire sizing

A. In order to understand tire sizing, it is first important to have an understanding of aspect ratio. Aspect ratio is the relationship of a tire's height to it's width. Another term for aspect ratio is profile or series. For example, a 70-series tire is 70% as tall as it is wide. The most common series are 60, 70, 75, and 80.



B. Metric sizing of tires is widely used today. A typical P Metric size would be P225/75R15. Below is an explanation of the letters and numbers that might appear on a typical metric tire size.

P = passenger car tire

225 = tread width in millimeters when
mounted on the proper rim

75 = aspect ratio (series)

R = radial-ply construction

15 = rim diameter in inches

C. Alpha numeric sizing was once the accepted standard by which tires were sized. The alpha numeric system was eventually replaced by metric sizing. A typical alpha numeric size would be FR70-15. Below is an explanation of what the letters and numbers mean.
F = size range

R = radial-ply construction

70 = aspect ratio

15 = rim diameter in inches

D. Most tires sold today are of the metric size designation. Conversion charts are used to determine which sizes are comparable.

IX. A convenience (space saver) spare tire is a small tire mounted on a special narrow rim. The space saver spare tire allows more space in the vehicle's luggage compartment than a full-size spare tire. Inflation pressure of convenience tires (usually less than that of standard tires) is molded into the tire sidewall. Some convenience spare tires will come with an aerosol bottle which is used for inflation.

(**NOTE:** The convenience spare tire and wheel are not interchangeable with the other tires and wheels on the vehicle.)

(CAUTION: A convenience tire is designed for use as a spare tire only. It should never be used as a replacement tire. A vehicle should be driven only short distances at reduced speeds when a convenience tire is being used.)

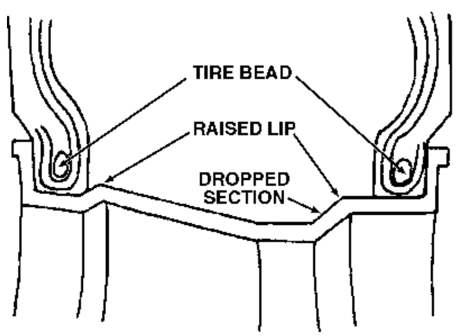
X. Wheels

A. Wheel construction

1. The common automobile wheel is made from stamped steel. The wheel consists of two pieces—the center and the rim. The center section is riveted or spot welded to the rim (the outer portion). The wheel has between four and six mounting holes for attaching the wheel to the wheel hub. The mounting holes are tapered to match tapered wheel nuts. The tapering helps to center the wheel on the wheel studs.

2. Most wheel rims are drop-center safety rims. Drop-center refers to the depression in the inner circumference of the rim. This depression allows one tire bead clearance while the other bead is being stretched over the rim.

3. Safety wheels have a raised lip inboard of each bead seat. This lip helps to prevent the bead from unseating if the vehicle corners hard or if the tire goes flat while the vehicle is moving.

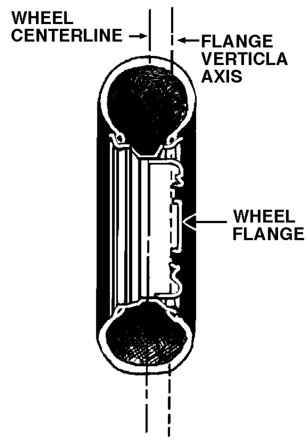


4. A hole in the rim accepts the tire valve stem. Air is added to or removed from the tire through the valve stem and core. The valve stem may be made of rubber, in which case it snaps into the hole. The stem may also be made of metal and held in place with a nut. The valve stem is located inside the valve core.

B. Wheel offset

1. Factory-installed wheels are designed with proper clearance for brake and suspension components. These wheels are also designed to distribute vehicle load evenly on the wheel bearings. Offset is the relationship between the vertical center line of the rim and the mounting flange of the wheel center. Usually the center line of the rim is inboard of the wheel's true centerline.

2. When replacing a wheel or installing an aftermarket wheel, use a wheel that has the same offset as the original. Many aftermarket wheels have an offset different from the original factory wheel. A difference in offset can affect wheel alignment, which, in turn, can affect handling and tire wear. A difference in offset can also affect weight distribution, causing premature failure of wheel bearings and spindles.



MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XV: WHEELS AND TIRES

LESSON 2: TIRE INSPECTION AND ROTATION

I. Tire inspections

A. Inflating tires

1. Every tire should be inflated to the factory-recommended pressure. The recommended tire pressures for a vehicle's original tires can be found on a decal, which is usually located either on the rear face of the driver door or the owner's manual. However, if the original tires have been replaced, it is recommended that the tire be inflated to the tire manufacture's specification. The tire manufacturer stamps the correct air pressure range on the sidewall of the tire.

2. Tire pressure should be checked while the tires are cool (at 50°F to 70°F). The tires will usually be sufficiently cool after the car has been immobile for about three hours or if the car has been driven less than one mile.

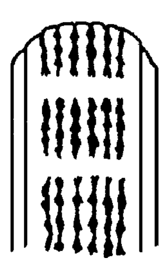
   (**NOTE:** Tire pressures can increase as much as 6 psi when the tires become hot.)

3. Inflation pressure should be tested with a pencil-type tire gauge at least once a month or before a long trip. The spare tire should also be checked. Stem caps should be reinstalled after pressures are checked. If stem extensions are used, make sure they are in place. If stem caps and valves are not in place, dirt and moisture may enter the valve core, causing leaks.

B. Procedure for checking tire wear and condition

1. Carefully raise and support the vehicle on a hoist.

2. Most tires have built-in tread wear indicators, which appear as 1/2" wide bands when the tread is worn to 1/16". If the indicators appear in two or more adjacent grooves at three or more locations around the tire, the tire should be replaced.



3. Inspect tires for exposed tread fabric. Replace any tire that has worn through the tread.

4. Inspect tires for lumps or knots caused by broken or damaged tire plies. Replace tires which have such lumps or knots.

5. Inspect tires for deep cuts—especially cuts that expose the fabric. Replace any tire that has deep cuts.

6. Inspect tires for flat spots on the tread surface. Flat spots are caused by hard brake applications at high speeds or defective tire construction. Tires with flat spots must be replaced.

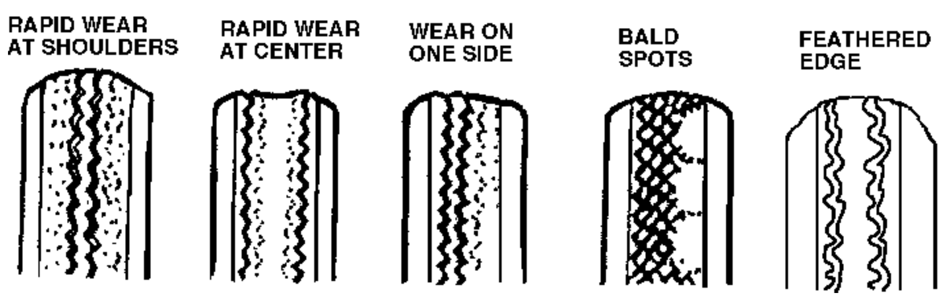
7. Inspect tires for foreign objects (nails, screws, etc.) which have penetrated the tire. If found, the tire must be repaired or replaced.

8. Inspect tires for missing valve stem caps or extensions. If missing, they should be replaced.

9. Inspect tires for signs of tread separation. Separations will resemble blisters on the tire's tread or sidewall.

10. Inspect tires for broken or bent wheels. If damage is found, the wheel must be replaced. To ensure the wheel is straight, spin each tire and wheel assembly by hand and watch for excessive runout (wobble).

11. Inspect tires for abnormal wear caused by improper wheel alignment. The illustration below shows various tire conditions and their possible causes.



II. Procedures for removing the tire and wheel assembly

A. Remove the wheel cover. Using a suitable prying tool, carefully pry off the wheel cover.

(**NOTE:** If the wheel is equipped with a locking-type wheel cover, remove the trim cover from the lock bolt. Next, use a special wheel bolt wrench to remove the lock bolt.)

(CAUTION: Many wheel covers have very sharp metal edges. Handle wheel covers carefully to avoid injury.)

(**NOTE:** Take care not to damage the wheel cover during removal.)

(**NOTE:** The owner's manual should be consulted if wheel covers are difficult to remove.)

B. Loosen the lug nuts one turn.

(**NOTE:** Some vehicles are equipped with one antitheft lug nut on each wheel. A special socket or key must be used to remove the antitheft wheel nut.)

C. Safely raise the vehicle until the tires are off the floor; then secure the vehicle.

D. Remove the lug nuts and remove the wheel.

III. Procedures for installing tire and wheel assemblies

A. Clean dirt and corrosion from the wheel hub mounting area and from the center pilot hole of the wheel.

B. Place the wheel on the hub and install the lug nuts finger tight.

C. Using the proper wrench, tighten the nuts alternately to draw the wheel evenly against the hub.

D. Lower the vehicle and finish tightening the lug nuts to the manufacturer's specified torque.

E. Install the wheel cover. Hit the cover only around the outer circumference with a soft rubber mallet.

IV. Rotating the tires

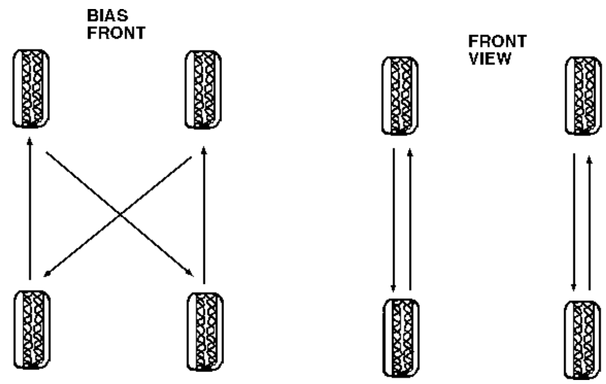
A. Rotating tires involves moving the tire to a different location on the vehicle. Since tires wear differently and at different rates, they should be rotated every 7500 miles or at intervals specified by the tire manufacturer.

(CAUTION: If abnormal tire wear is discovered during rotation, the cause should be corrected before the rotation is complete.)

(**NOTE:** The spare tire may be included in the rotation if it is a full-size tire. Do not include convenience spare tires in the rotation.)

B. Procedures for rotating tires

(**NOTE:** Tires can be rotated in various patterns; however, the rotation pattern must meet the tire manufacturer's recommendation. For example, some radial tires are unidirectional—that is, their rotation pattern will resemble more closely the bias rotation pattern than a typical radial rotation pattern.)



1. Loosen tire and wheel assemblies as described earlier in this lesson.

2. Safely raise and support the vehicle so that all four wheels are off the ground.

3. Rotate the tire and wheel assembly in the chosen pattern.

4. Tighten all lug nuts evenly. Make sure to tighten them to the recommended torque.

   (CAUTION: Some tires are directional—that is, they have a special tread designed to roll in only one forward direction—and may not be crossed from one side of the vehicle to the other. This type of tire normally has an arrow molded into the sidewall, indicating the direction of rotation.)
   (CAUTION: Some wheels are directional—that is, they can only be rotated in one direction—and cannot be moved from one side of the vehicle to the other. The purpose of directional wheels is to aid the cooling of the brakes.)

C. Convenience spare tires should never be included in tire rotation.

JS1-L2-UXV

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND INFLATING TIRES

Equipment:

Hoist
Pencil-type tire gauge
Serviceable vehicle
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Place the vehicle securely on safety stands or safely lift it with a hoist.

3. Visually inspect each tire for wear or damage. Record in the spaces below the results of the inspection.

   Is tread wear abnormal? YES_____ NO_____

   Are there punctures? YES_____ NO_____

   Are there lumps or knots? YES_____ NO_____

   Are there exposed cords? YES_____ NO_____

   Are the valve stems damaged? YES_____ NO_____

   Are there flat spots? YES_____ NO_____

   Are radial and bias tires on the same axle? YES_____ NO_____

   Do the tire sizes vary? YES_____ NO_____

   If "YES" was the answer to any of the above questions, describe the problem and suggest the appropriate action to be taken. If abnormal tread wear was noted during the inspection, be sure to identify the cause.

4. Spin each tire and wheel assembly while noting any wobble (lateral or radial runout). Record observations.

5. Determine the proper inflation pressure for the vehicle being inspected. Record the pressures in the spaces below. Lower the vehicle.

   Cold inflation pressure

   Front tires ____________

   Rear tires _____________

   Spare tire _____________

JS2-L2-UXV

MODULE: STEERING AND SUSPENSION SYSTEMS

ROTATING TIRES

Equipment:

Hoist
Wheel wrench
Torque wrench
Hand tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Place the vehicle securely on safety stands or safely lift it with a hoist.

3. Using a service manual or other information source, locate a procedure for determining the rotation pattern to be used for rotating the tires. Be sure to identify the front and rear of the vehicle. Be sure to also determine the lug nut torque sequence and the final torque specifications. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the procedure, rotate the vehicle's tires.

   a. Inspect the condition of the tires during the rotation. Record observations.

   b. Inspect the condition of the wheel studs and nuts. Record observations. Replace any defective wheel studs or nuts as directed by the instructor.

c. Inflate all tires to the recommended pressure.

d. Tighten all wheel nuts to the specified torque and lower the vehicle.

(**NOTE:** To prevent rotor distortion, do not use an air wrench to replace lug nuts on hubs with disc brakes.)

(**NOTE:** Use only a soft-faced rubber mallet to install the wheel covers.)

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XV: TIRES AND WHEELS

LESSON 3: TIRE MOUNTING AND PUNCTURE REPAIR

I. Procedures for dismounting tires

(**NOTE:** Dismounting or mounting tires should only be done with a tire machine. Using tire irons or pry bars to mount or dismount tires can damage tire beads.)

(**NOTE:** If the tire tread is directional, note the direction of the tread before mounting.)

A. Deflate the tire by removing the valve core with a valve core tool.

B. Using wheel weight pliers, remove all wheel weights.

C. Mount the tire and wheel assembly securely on the tire changer according to the instructions provided by the manufacturer of the tire changer.

D. Break the beads loose from the rim according to the instructions provided by the manufacturer of the tire changer.

E. Lubricate both beads with a tire rubber lubricant or a mild soapy water solution to prevent bead damage and ease removal.

(**NOTE:** Do not use petroleum-based oil or silicone as a lubricant.)

F. Remove the tire beads according to the instructions provided by the manufacturer of the tire changer.

(CAUTION: Failure to follow the tire machine instructions carefully could result in serious personal injury.)

(**NOTE:** Do not force or allow the dismounting tool to hang up on the tire beads. Bead damage may result.)

II. Procedures for mounting tires

A. Clean the wheel. Both bead seats must be free of dirt and rust. Use a wire brush to clean the bead seats.

B. Inspect the wheel for damage.

(**NOTE:** Wheels that are cracked or obviously bent must be replaced. Wheels that are suspected of being bent or distorted should be tested for excessive runout. The procedure is discussed later in this module.)

C. Inspect the valve stems according to the procedure outlined below.

1. Bend rubber valve stems from side to side and look for signs of deterioration or cracking.

2. If the stem is bad, replace it.

   (**NOTE:** It is good practice to replace the valve stems when mounting new tires.)

3. Apply rubber lubricant to the new stem and pull it through the hole in the rim. (A special tool is made for this purpose.)

D. Inspect the tire to be mounted according to the procedure outlined below.

1. Inspect the condition of the tire beads. Tires with badly torn or damaged beads should be discarded.

2. Inspect for punctures or damage to the tire tread or sidewall.

3. Clean any foreign material from inside the tire.

E. Lubricate both tire beads with rubber lubricant or a mild soapy water solution.

(CAUTION: Inadequate lubrication can damage beads or make installation and bead seating difficult. Too much lubrication can cause the tire to slip on the rim.)

F. Following the instructions provided by the manufacturer of the tire changer, mount the tire on the wheel.

G. Inflate and inspect the tire according to the procedure outlined below.

1. Inflate the tire until both beads pop out on the rim. Do not allow pressure to exceed 25 psi. Popping out beads at pressures over 25 psi can damage the rim. If the tire continues to inflate but will not pop, do not continue to add air. Deflate the tire and break and relube the beads before continuing.

   (CAUTION: Keep fingers out and away from the bead seating area while popping the beads up.)

2. After the beads have popped, continue to inflate the tire to 40 psi. Passenger car tires should never exceed 40 psi.

   (**NOTE:** This additional pressure helps to seat the beads properly on the rim.)

3. Install the valve core and inflate tire to the recommended pressure.

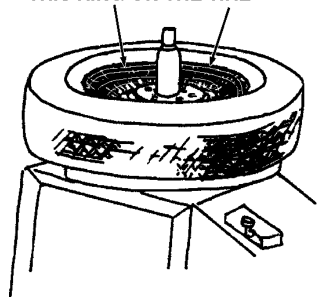
4. Place some soapy water in the valve stem at the valve core. Bubbles in the water indicate leaks.

   (**NOTE:** Leaks around the valve core are not uncommon. If leaks are discovered, loosen the valve core. Retighten and recheck the core. If it still leaks, replace the valve core and recheck for leakage.)

5. Install the valve stem cap or valve stem extension.

H. Visually inspect the tire for uneven bead seating.

(**NOTE:** The distance from the edge of the rim to the concentric rim locating ring should be equal around the circumference of the tire. A tire that is not concentric with the rim cannot be balanced accurately and may have excessive runout, both of which will result in unacceptable performance. If the wheel and tire are not concentric, deflate the tire and break and reseat the beads.)



(**NOTE:** The concentric rim locating ring is molded into the tire. The ring is visible just outside of the rim when the tire is mounted on the wheel.)

III. Procedures for repairing a tubeless tire

(**NOTE:** Steps A-F deal with all tire repairs. Step G deals with the patch-plug method and step H deals with the patch method.)

(CAUTION: Plug repairs or aerosol sealants provide only temporary repair. Permanent tire repairs can be achieved only by using one of the procedures outlined below.)

A. If a tire is suspected of having a leak, inflate the tire to the maximum recommended pressure and either immerse the tire in a tank of water or apply a soapy water solution to all areas of the tire. In either case, bubbles will appear at the leak.

(**NOTE:** In addition to the tire, valve stems, valve cores, and wheels are sometimes the cause of leakage.)

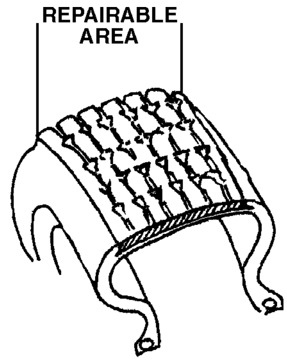
B. After the puncture is located, mark the hole with a tire crayon and then dismount the tire.

C. Remove the foreign object that caused the puncture (if the object is still in the tire).

D. Mount the tire in a tire spreading tool.

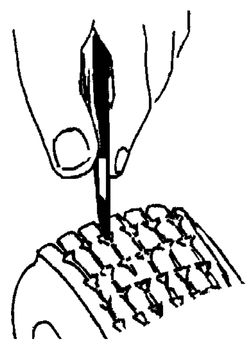
E. Inspect the tire for damaged beads. Tires with badly torn beads should be discarded.

F. Inspect the tire for cuts, exposed cord, separations, etc. as described earlier in this unit. (**NOTE:** Punctures and nail holes up to 1/4" diameter that are confined to the tread area may be repaired permanently only from inside the tire. Never repair tires worn below 1/16". The illustration below shows the normal repairable area of a tire.)

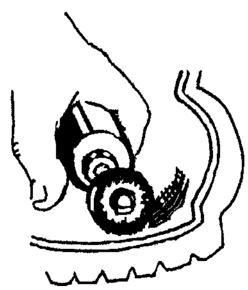


G. Installing a patch-plug

1. Clean out the puncture with a tungsten carbide rod tool.



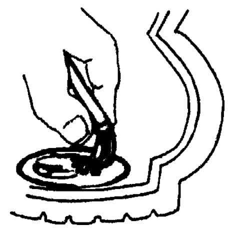
2. Buff the area with a tungsten carbide buffing wheel driven by a 3/8" drill or pneumatic tool. Buff to achieve a finely grained bonding surface.



3. Do not burn the rubber with the buffing wheel. Do not buff until the cord body is exposed through the inner rubber lining.

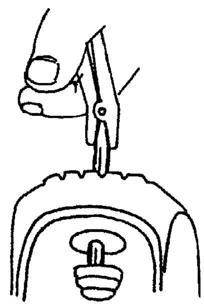
4. Clean the buffing dust from the inside of the tire.
(**NOTE:** Do not use petroleum solvent to clean the buffed area. Petroleum may neutralize the chemicals in the patching cement.)

5. Apply an even coat of patching cement to the puncture and the buffed area. Allow the cement to dry thoroughly.

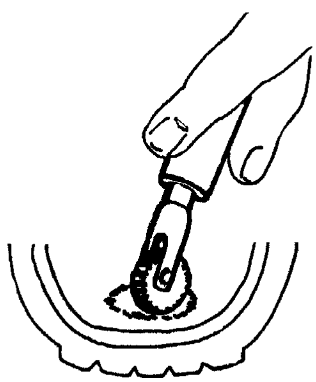


6. Select a patch plug which has a stem slightly larger than the puncture. Remove the protective backing from the patch plug.

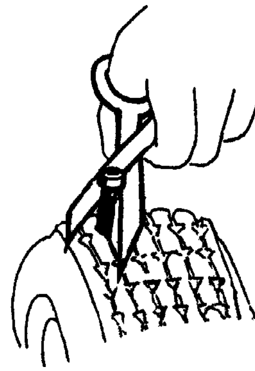
7. Coat the patch plug with cement and insert it through the puncture. A special installation tool may be used to pull the plug through the hole. Pull until the base of the patch presses against the tire.



8. Bond the patch firmly to the tire by rolling over the patch with a patch wheel. Keep strokes close together to avoid trapping air under the patch.



9. Cut off the protruding end of the plug approximately one-eighth of an inch above the tread surface.



10. Remount the tire and check the repair for leaks by either immersing it in a water tank or applying soapy water to the punctured area.

11. Rebalance the tire.

    (**NOTE:** When repairing radial tires, use only patches or patch plugs which are designated for radial tires.)

H. Installing a tire patch

(NOTE: Follow procedures A-F as outlined above.)

(NOTE: Repairing a tire with a patch is similar to repairing it with a patch plug.)

1. Buff the inner surface of the tire in the same manner as described in the patch plug method. Clean the buffing dust from the tire.

2. Probe the tire to ensure nothing is still in the puncture.

   (CAUTION: Do not use a tungsten carbide rod as described in the patch plug procedure. Doing so will enlarge the puncture.)

3. Coat the buffed area with patching cement and allow it to dry.

4. Peel the protective backing from the patch and center it over the puncture. Bond the patch carefully to the tire.

5. Remount the tire and check the repair for leaks by either immersing it in a water tank or applying soapy water to the punctured area.

6. Rebalance the tire.

JS1-L3-UXV

MODULE: STEERING AND SUSPENSION SYSTEMS

DISMOUNTING AND MOUNTING TIRES

Equipment:

Tire changer
Tire pressure gauge
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. If necessary, remove the tire and wheel assembly from the vehicle.

3. Remove the valve core to deflate the tire.

4. Remove any wheel weights from the wheel.

5. Mount the tire on the tire machine and dismount the tire according to the machine's instructions.

   (CAUTION: Failure to follow manufacturer's instructions when operating a tire machine could result in serious personal injury.)

   (**NOTE:** In order to make bead removal easier and to prevent damage, apply rubber lubricant to both beads before dismounting.)

6. Inspect the wheel and answer the following questions.

   Is the rim damaged or bent? YES_____ NO_____

   Are the rim bead seats rusted? YES_____ NO_____

   Is the wheel broken or cracked? YES_____ NO_____

   Is the valve stem in bad condition? YES_____ NO_____

   If "YES" was the answer to any of the above questions, describe what action should be taken to correct the problem.

7. Following the procedure outlined below, inspect the tire to be mounted.

    a. Inspect the beads. If the beads are badly torn, the tire should be discarded.

    b. Check for any punctures in the tire. Repairable punctures should be patched before mounting. See JS2-L3-UXV for this procedure.

    c. Check for wear or damage to the tire tread or sidewall. Defective tires should be discarded.

    d. Check for and remove any foreign material from inside the tire.

    e. Record any problems found in the space below.

8. Clean the bead seating area of the rim prior to mounting the tire. Replace any defective tires, wheels, or valve stems as directed by the instructor.

9. Mount the tire on the wheel according to the tire machine manufacturer's instructions.

    a. Apply rubber lubricant to both beads before mounting.

    (CAUTION: Do not exceed 25 psi when popping the tire beads. Keep fingers clear of the tire when seating the bead on the rim.)

    b. Inflate to 40 psi to seat beads after beads have popped.

    c. Install the valve core and inflate to the specified pressure.

    d. Check for leaks at the valve core. Repair leaks if discovered.

    e. Install the valve stem cap or extension.

10. Reinstall the tire and wheel assembly on the vehicle, if required.

JS2-L3-UXV

MODULE: STEERING AND SUSPENSION SYSTEMS

REPAIRING PUNCTURES IN TUBELESS TIRES

Equipment:

Tire machine
Tire spreader
Tire pressure gauge
Tire buffer
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. If required, remove the tire and wheel assembly from the vehicle.

3. Locate and mark the puncture.

4. Remove the foreign object causing the puncture.

5. Dismount the tire. For this procedure, refer to JS1-L3-UXV.

6. Mount the tire in a tire spreader and inspect the condition of the tire. Answer the questions below.

   Is the puncture repairable? YES_____ NO_____

   Is the bead in good condition? YES_____ NO_____

   Is tire wear normal? YES_____ NO_____

   Is the tire in good general condition? YES_____ NO_____

   If "NO" was the answer to any of the above questions, describe the problem and recommend repairs.

7. Determine and record below the type of repair to be made. Consult the instructor for directions.

8. Probe the puncture to make sure all foreign material is removed.

9. Following the procedure outlined below, repair the tire.

   a. Prepare the area to be patched according to the type of patch to be used.

   b. Remove all buffing dust from the tire.

   c. Apply tire patch cement and allow it to dry thoroughly.

   d. Install the patch and bond the patch to the tire.

   e. Cut off excess patch plug (if used).

10. Mount the repaired tire on the wheel. For this procedure, refer to JS1-L3-UXV.

11. Test the repair for leaks. Record the results in the space below.

12. Balance the tire.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XVI: WHEEL RUNOUT AND BALANCE

UNIT OBJECTIVE

After completing this unit, the student will be able to test tire and wheel runout and perform static and dynamic balance on tire and wheel assemblies. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the differences between static and dynamic balance (Competency U4, Unit XVI Test).

II. Identify the characteristics of wheel runout (Competency U4, Unit XVI Test).

Lesson 2.

I. Identify the procedures for testing radial runout of wheel and tire assemblies (Competency U4, Unit XVI Test).

II. Identify the procedures for testing lateral runout of the wheel and tire assemblies (Competency U4, Unit XVI Test).

III. Identify the procedures for checking lateral and radial runout of the wheel assemblies (Competency U4, Unit XVI Test).

IV. Identify the procedures for match mounting a tire and wheel assembly (Competency U4, Unit XVI Test).

V. Identify the procedures for balancing tire and wheel assemblies (Competency U4, Unit XVI Test).

VI. Demonstrate the ability to:

   a. Measure tire and wheel assembly for lateral and radial runout (Competency U1, JS1-L2-UXVI).

   b. Balance tire and wheel assemblies (Competency U4, JS2-L2-UXVI).

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XVI: WHEEL RUNOUT AND BALANCE

CONTENTS OF THE UNIT

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XVI: WHEEL RUNOUT AND BALANCE

LESSON 1: PRINCIPLES OF WHEEL BALANCE AND RUNOUT

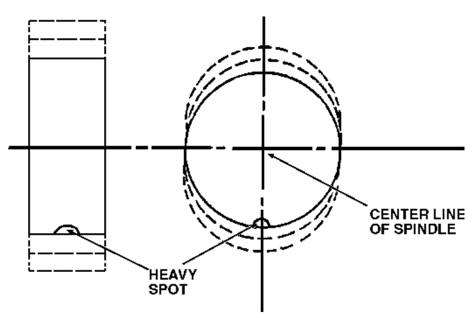
I. Static and dynamic balance

A. If a tire and wheel assembly is heavier at one point than another, the assembly is said to be out of balance. Imbalanced wheel assemblies result in a rough ride. Imbalanced wheel assemblies also shorten the life of the tires and damage steering and suspension components. Tires can be balanced by using either the static method or the dynamic method.

B. Static balance

1. Static balance means the weight of the tire and wheel assembly is distributed equally around the axis of wheel rotation (the spindle). If a tire and wheel assembly is in static balance, the wheel will have no tendency to rotate on its own, regardless of its position. If the tire and wheel assembly is not statically balanced, the assembly will roll on its own until the heavy spot is at the bottom.

2. A statically out-of-balance wheel assembly will tramp or hop as the car moves down the road. The speed at which the tramp occurs depends upon the degree to which the wheel is out of balance. The greater the imbalance, the lower the speed at which the tramp will be noticed.

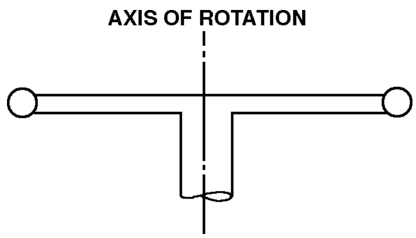


C. Dynamic balance

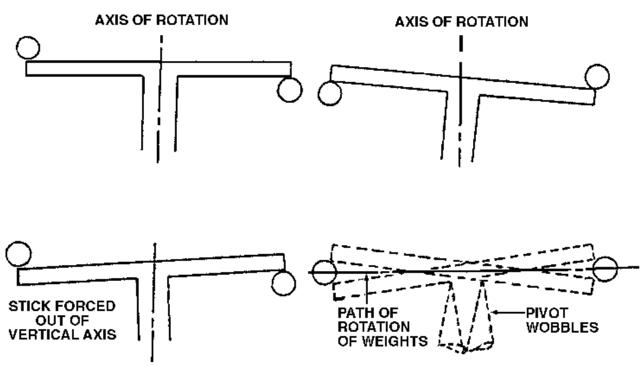
1. Dynamic balance can be defined as balance in motion. If a wheel assembly is in dynamic balance, it must also be in static balance. However, a wheel assembly that is balanced statically is not necessarily balanced dynamically.

2. To achieve dynamic balance, weight must be distributed equally around the axis of rotation. Weight must also be distributed equally in regard to the centerline of the tire and wheel assembly. Listed below are some principles of dynamic balance.

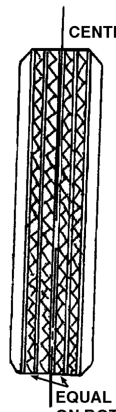
a. Imagine a stick with equal weights attached to each end. Imagine this same stick attached to a pivot as shown in the illustration below. If the stick were spun around, the path of its rotation would be at a right angle to the pivot (axis of rotation).



b. If the weights are shifted as shown in the illustration below, the stick will remain in static balance. However, if the stick is spun with the weights in their shifted position, the stick will be forced out of its axis of rotation due to dynamic imbalance. The stick will tend to wobble each half revolution due to the heavy weights, attempting to line up with the center of rotation.



c. To compensate for this dynamic imbalance, weight must be placed equally around the centerline of the stick. In the case of an automobile wheel, the same is true: weights must be placed around the centerline of the tire as indicated in the illustration below.



d. Correcting the dynamic balance of the tire also corrects any static imbalance.

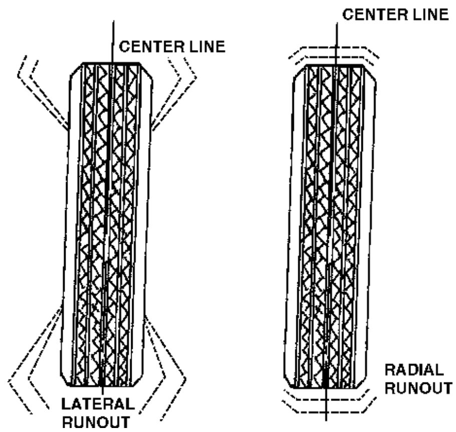
II. Wheel runout

A. When wheel tramp or vibration is evident, the cause must be determined before corrective action can be taken. In addition to improper balance, radial or lateral wheel runout may be causing the tramp or vibration.

(**NOTE:** When wheel tramp or vibration is evident, it is advisable to check runout before balancing a wheel.)

B. A tire and wheel assembly with excessive radial runout is commonly referred to as being out of round. In a tire and wheel assembly with radial runout, the distance from the spindle to the ground changes as the assembly rotates, thus causing the assembly to hop or tramp.

C. Lateral runout is a sideways wobble of the tire and wheel assembly. The wobble occurs as the assembly rolls. Lateral runout is often referred to as shimmy. If the front wheels have lateral runout, the steering wheel may oscillate.


CENTER LINE
LATERAL
RUNOUT
CENTER LINE
RADIAL
RUNOUT

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XVI: WHEEL RUNOUT AND BALANCE

LESSON 2: TESTING FOR AND CORRECTING WHEEL ASSEMBLY RUNOUT AND IMBALANCE

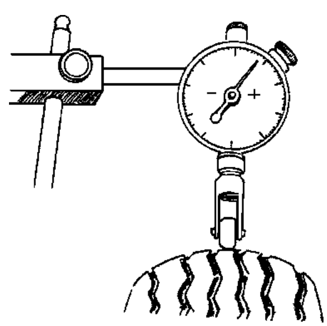
I. Procedures for testing the radial runout of the wheel and tire assembly (out of round)

(**NOTE:** Before testing runout, the vehicle should be driven in order to warm the tires and eliminate any irregularities that may have developed as a result of the vehicle being stationary.)

(**NOTE:** Check and, if necessary, correct wheel bearing adjustment.)

A. Safely raise and secure the vehicle. Make sure the tires are raised 3 to 4 inches off the floor.

B. Position the wheel and tire runout gauge (a dial indicator with a roller attached to the plunger) on the center rib of the tire.



C. Rotate the wheel one full revolution and zero the runout gauge at the low spot of the tire and wheel assembly.

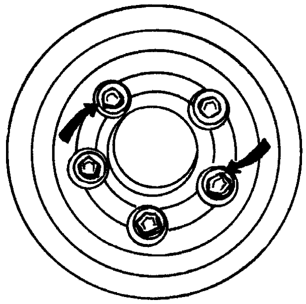
D. Rotate the wheel again and mark the high spot on the tread. Also mark the wheel bolt nearest the high spot on the tire.

(**NOTE:** The specification for radial runout is usually no more than .125 of an inch. Check the proper service manual for the vehicle to be serviced.)

E. If radial runout is within specifications, the radial runout test is complete and the lateral runout test can be performed. Refer to the information on lateral runout tests found later in this lesson.

F. If radial runout is not within specifications, perform the procedure outlined below.

1. Unbolt the wheel and rotate it two studs on the hub. Repeat steps C and D above.



2. If, after performing steps C and D above, runout is still excessive, mark the location of the new high spot on the tire. If this second high spot mark is near the first high spot mark, the runout is caused by either the wheel or the tire. In this case, the tire and wheel should be match mounted. (Refer to the match mounting information presented later in this lesson.) If the second high spot mark lines up with the first wheel stud mark, the hub or the hub assembly is defective and should be replaced.

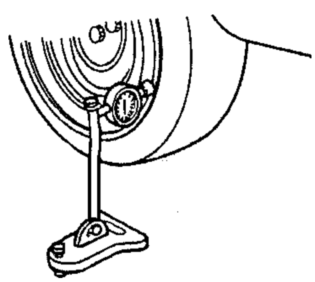
II. Procedures for testing the wheel and tire assembly for lateral runout (wobble)

(**NOTE:** Before testing runout, the vehicle should be driven in order to warm the tires and eliminate any irregularities that may have developed as a result of the vehicle being stationary.)

(**NOTE:** Check and, if necessary, correct wheel bearing adjustment.)

A. Safely raise and secure the vehicle. Make sure the tires are raised 3 to 4 inches off the floor.

B. Position the wheel and tire runout gauge (a dial indicator with a roller attached to the plunger) on the tire sidewall. Make sure it is as close to the tire shoulder as possible without interference from the markings on the outside of the tire.



C. Rotate the wheel one revolution. Mark the low spot on the tire and zero the gauge.

D. Rotate the wheel again and mark the high spot on the tread. Also mark the wheel bolt nearest the high spot on the tire.

(**NOTE:** The specification for lateral runout is usually no more than .060 of an inch. Check the proper service manual for the vehicle to be serviced.)

E. If lateral runout is within specifications, the lateral runout test is complete.

(**NOTE:** If both radial and lateral runout are within specifications, the wheel and tire assembly should be balanced.)

F. If lateral runout is not within specifications, perform the procedure outlined below.

1. Unbolt the wheel and align the low spot mark on the tire as closely as possible to the wheel bolt that was marked as the high spot in step D above.

2. Repeat steps C and D above.

3. If, after performing steps C and D above, lateral runout is still excessive, mark the location of the new high spot on the tire. If this second high spot mark is near the first high spot mark, the runout is caused by either the wheel or the tire. In this case, the tire and wheel should be match mounted. (Refer to the match mounting information presented later in this lesson.) If the second high spot mark is near the low spot marked in the first observation, the hub or hub assembly is defective and should be replaced.

III. Procedures for checking the wheel for lateral and radial runout

A. Remove the wheel from the vehicle and dismount the tire.

B. Reinstall the wheel on the vehicle and tighten wheel nuts evenly to the specified torque.

C. Place the dial indicator on the vertical and horizontal bead seats and measure the lateral runout and then the radial runout while rotating the wheel.

D. If the runout is excessive when compared to specifications, replace the wheel. (**NOTE:** The specification for wheel lateral and radial runout is usually half the wheel/ tire specified tolerance.)

IV. Procedures for match mounting a tire and wheel assembly

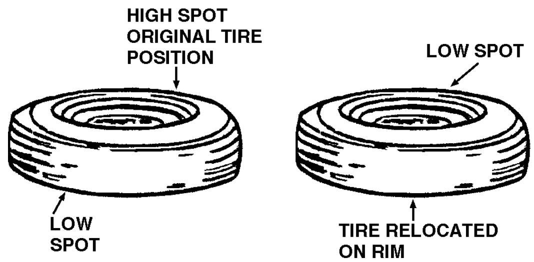
(**NOTE:** The procedure for match mounting a tire and wheel assembly is the same for correcting both radial and lateral runout.)

A. Mark the runout high spot on the wheel and tire.

B. Using a tire machine, deflate the tire and break the beads loose.

C. Measure the lateral and radial runout of the wheel as described earlier in this lesson. If the wheel is defective, replace it.

D. Rotate the tire on the rim 180 degrees from its original position. Inflate the tire to the specified pressure.



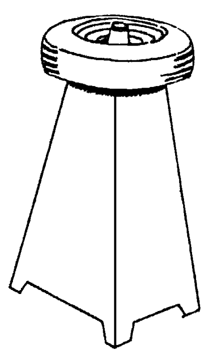
E. Install the wheel on the vehicle and recheck the runout. If runout is within specifications, proceed with balancing the tire. If runout is still excessive, the tire must be replaced.

V. Balancing a wheel

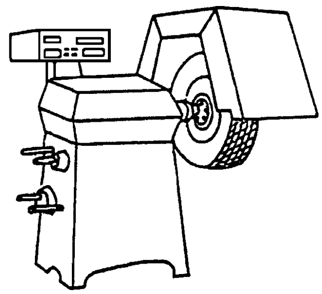
A. Wheel imbalance is corrected by determining the location of the imbalance and then determining where to place weights to correct the imbalance.

B. Two types of wheel balancers are the bubble balancer and the off-vehicle computerized balancer.

1. The bubble balancer works much like a carpenter's level. If the tire has a heavy spot, the balancer will tilt and throw the bubble off center. (Off center is indicated by the bubble moving out of a circle on the balancer.) Weight is then applied at various positions on the tire. When the proper amount of weight is added at the proper locations, the bubble moves back into the center of the circle. A bubble balancer can achieve only a static balance.



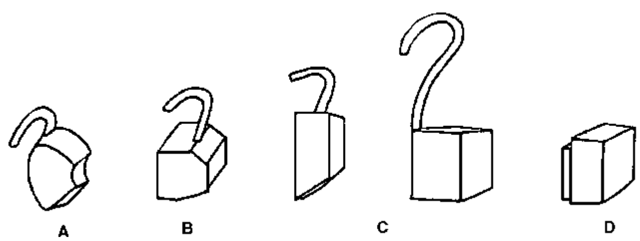
2. An off-vehicle computerized balancer is the most commonly used balancer today. The computerized balancer is simple to operate and achieves a high degree of accuracy. This type of balancer corrects both static and dynamic imbalance. After spinning the tire and wheel assembly, the balancer indicates how much weight is needed and where the weight should be placed.



C. Wheel weights

1. Wheel weights are made of lead. Wheel weights range from 1/4 ounce to several ounces. Wheel weights are usually marked in both ounces and grams.

2. Wheel weights are usually attached to the rim by steel clips, which are molded into the lead weight. Stick-on weights are also available for custom wheels. The illustration below shows some of the various types of weights available.



D. Procedure for balancing wheels

1. Before balancing tires with any type of balancer, clean any foreign material from the tire tread and wheel assembly. Even small pebbles can affect wheel balance.

2. Inspect the tire condition. Discard tires with tread worn to 1/16 inch or less. Also discard tires with bulges, separations, or other obvious damage.

3. Remove all old wheel weights.

4. Balance the wheel according to the directions provided by the manufacturer of the balancer.

5. Install weights securely on the wheel. Loose weights can fly off while the car is moving.

6. Recheck wheel balance after weights are installed.

JS1-L2-UXVI

MODULE: STEERING AND SUSPENSION SYSTEMS

MEASURING TIRE AND WHEEL ASSEMBLY LATERAL AND RADIAL RUNOUT

Equipment:

Dial indicator
Serviceable vehicle
Tire machine
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. After obtaining permission from the instructor, drive the vehicle to warm the tires and eliminate flat spots.

3. Place the vehicle securely on safety stands or safely lift it with a hoist.

4. Check and correct wheel bearing adjustment (when applicable).

5. Using a service manual or other information source, locate a procedure for determining the maximum allowable radial and lateral runout for the tire and wheel assembly. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

6. Test radial runout of the tire and wheel assembly.

   a. Position a runout gauge on the center rib of the tire.

   b. Rotate the wheel one full revolution. Zero the runout gauge at the low spot of the tire and wheel assembly.

c. Rotate the wheel again and mark the high spot on the tread. Also mark the wheel bolt nearest the high spot. Record runout below. Compare runout to the specification recorded in item 5 of this job sheet. If runout is within acceptable limits, go to item 7 of this job sheet. If runout is not within acceptable limits, go to item 7 below.

Radial runout _____________

7. Unbolt the wheel and rotate it two studs on the hub. Repeat steps 6 a, b, and c above. If runout is still excessive, mark the location of the high spot. Answer the questions below.

a. Is the new mark near the high spot marked in c of item 6 above?

YES_____ NO_____

b. Does the new mark line up with the wheel stud mark?

YES_____NO_____

c. Based on the results of step 7, indicate which corrective procedures (if any) should be performed.

Corrective action needs to be taken.

YES_____NO_____

Match mounting should be performed.

YES_____NO_____

(**NOTE:** If match mounting must be performed, proceed to item 8 below.)

8. Following the procedure outlined below, match mount the wheel and tire assembly.

a. Mark the runout high spot on the wheel and tire.

b. Using a tire machine, deflate the tire and break the beads loose.

c. Measure the lateral and radial runout of the wheel as described earlier in this module. If the wheel is defective, replace it.

d. Rotate the tire on the rim 180 degrees from its original position. Inflate the tire to the specified pressure.

e. Install the wheel on the vehicle and recheck the runout. If runout is within specifications, proceed with balancing the tire. If runout is still excessive, the tire must be replaced.

f. Record the results of the match mounting procedure below.

9. Test the tire and wheel assembly for lateral runout.

a. Place the runout gauge on the tire sidewall as close to the tire shoulder as possible.

b. Rotate the wheel one revolution. Mark the low spot on the tire and zero the gauge.

c. Rotate the tire again. Mark the high spot on the tire. Also mark the lug bolt nearest the high spot. Read and record the lateral runout in the space below.

Lateral runout _________________

d. Compare the lateral runout recorded above to the specification recorded in item 5 of this job sheet. If runout is within specification, this job sheet is complete. If runout is not within specification, go to step 10.

10. Unbolt the wheel and align the low spot mark with the marked wheel stud. Repeat steps 9 a, b, and c. If runout is still excessive, mark the position of the high spot and answer the questions below.

a. Is the marked wheel stud near the low spot marked in step b of item 9 above?

YES_____NO_____

b. Is the marked wheel stud near the high spot marked in step c of item 9 above.

YES_____NO_____

c. Based on the answers to questions a and b above, should the wheel hub and axle be either repaired or replaced?

YES_____NO______

JS2-L2-UXVI

MODULE: STEERING AND SUSPENSION SYSTEMS

BALANCING TIRE AND WHEEL ASSEMBLIES

Equipment:

Static/dynamic wheel balancer
Wheel weight pliers
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Place the vehicle securely on safety stands or safely lift it with a hoist.

3. Following the procedure developed in JS1-L2-UXVI, test the lateral and radial runout of the tire and wheel assembly to be balanced. Record the test results and compare them to the tire and wheel runout specifications recorded in item 5 of JS1-L2-UXVI. Is the tire and wheel runout within specifications?

   YES_____ NO______

   (**NOTE:** Excessive tire and wheel runout should be corrected before attempting to balance the tires. Consult the instructor if excessive runout is found.)

4. Inspect tire condition. Record any excessive wear or defects below.

5. Balance the tire and wheel assembly according to the instructions provided by the manufacturer of the balancer. Be sure to include the below steps in the balancing procedure.

   a. Remove any pebbles or foreign material lodged in the tire tread and wheel assembly.

   b. Remove old wheel weights.

   c. Install weights securely.

   d. Recheck balance after weights are installed.

6. Reinstall the tire and wheel assembly on the vehicle. Tighten wheel nuts to the specified torque. Lower vehicle.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XVII: WHEEL ALIGNMENT AND STEERING AND SUSPENSION DIAGNOSIS

UNIT OBJECTIVE

After completing this unit, the student should be able to correct all adjustable alignment angles on front and rear suspensions and diagnose problems related to steering, suspension, wheel alignment, and balance. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the causes of vibration at highway speeds (Competency U1, Part I of the Unit XVII Test).

II. Identify the characteristics and causes of wheel shimmy (Competency U1, Part I of the Unit XVII Test).

III. Identify the characteristics of rough or damaged wheel bearings (Competency U1, Part I of the Unit XVII Test).

IV. Identify the characteristics and causes of wander (Competency U1, Part I of the Unit XVII Test).

V. Identify the characteristics and causes of lateral pull (Competency U1, Part I of the Unit XVII Test).

VI. Identify the characteristics and causes of hard steering (Competency U1, Part I of the Unit XVII Test).

VII. Identify the characteristics and causes of poor steering return (Competency U1, Part I of the Unit XVII Test).

VIII. Identify the procedures for diagnosing wheel shimmy, vibration, wander, pull, and bearing noise during a road test (Competency U1, Part I of the Unit XVII Test).

IX. Demonstrate the ability to:

   a. Road test a vehicle for steering, suspension, and wheel alignment problems (Competency U1, JS1-L1-UXVII).

Lesson 2.

I. Identify the characteristics of wheel alignment (Competencies U2 and U3, Parts II and III of the Unit XVII Test).

II. Identify the various wheel alignment angles (Competencies U2 and U3, Parts II and III of the Unit XVII Test).

Lesson 3.

I. Identify the various types of wheel alignment equipment (Competencies U2 and U3, Parts II and III of the Unit XVII Test).

II. Identify the procedures for making pre-alignment checks (Competencies U2 and U3, Parts II and III of the Unit XVII Test).

III. Identify the manner in which wheel alignment angles are interrelated (Competencies U2 and U3, Parts II and III of the Unit XVII Test).

IV. Identify the procedures for adjusting front-wheel camber (Competency U2, Part II of the Unit XVII Test).

V. Identify the procedures for adjusting front-wheel caster (Competency U2, Part II of the Unit XVII Test).

VI. Identify the procedures for adjusting front-wheel toe (Competency U2, Part II of the Unit XVII Test).

VII. Identify the procedures for rear-wheel alignment (Competency U3, Part III of the Unit XVII Test).

VIII. Identify concepts relating to four-wheel alignment (Competency U2 and U3, Parts II and III of the Unit XVII Test.)

IX. Demonstrate the ability to:

a. Measure and correct front-wheel alignment (Competency U2, JS1-L3-UXVII).

b. Measure and correct rear-wheel alignment (Competency U3, JS2-L3-UXVII).

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XVII: WHEEL ALIGNMENT AND STEERING AND SUSPENSION DIAGNOSIS

CONTENTS OF THE UNIT

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XVII: WHEEL ALIGNMENT AND STEERING AND SUSPENSION DIAGNOSIS

LESSON 1: DIAGNOSING VARIOUS STEERING, SUSPENSION, AND WHEEL ALIGNMENT PROBLEMS

I. Sometimes a vehicle will vibrate at highway speeds. Some of the causes of vehicle vibration are listed below.

A. Poor road surface

B. Tire and wheel imbalance

C. Bent wheels or excessive radial or lateral runout

D. Defective tires

E. Improper tires for the vehicle

F. Drive line imbalance

G. Engine imbalance

H. Dragging or sticking brakes

II. Wheel shimmy is the shaking of the front wheels. Wheel shimmy usually begins at a lower speed than other types of vehicle vibration. The shimmy is usually transferred through the steering linkage, causing the steering wheel to shake back and forth. In some instances, shimmy can become severe enough to make the driver lose control of the vehicle. Listed below are some of the causes of wheel shimmy.

A. Wheel and tire imbalance

B. Excessive wheel and tire runout

C. Uneven tire pressure

D. Badly or abnormally worn tires

E. Defective tires

F. Wheels that are severely out of alignment

G. Defective steering stabilizer

H. Tires and wheels that are too large for the vehicle

I. Misaligned front-wheel-drive axles

III. Rough or damaged wheel bearings usually produce a low rumbling or growl at slow speeds. At higher speeds, rough wheel bearings will often make a howling or whining sound. Wheel bearing noise will usually increase and decrease as the steering is turned from side to side.

(**NOTE:** Certain types of pavement and uneven or unusual tire wear can produce noise similar to wheel bearing noise.)

IV. Wander (also referred to as directional instability) is a problem that requires the driver to make constant steering corrections to keep the vehicle in a straight path. Listed below are some of the causes of wander.

A. Low or uneven tire inflation

B. Badly worn tires

C. Incorrect front-wheel alignment

D. Incorrect rear-wheel alignment on front-wheel-drive vehicles

E. Incorrect steering gear adjustment

F. Loose wheel bearings

G. Worn steering pads

V. Lateral pull causes the vehicle to pull to one side as the car is driven straight on a level road. There are two types of lateral pull. One type occurs when the vehicle is in motion. The other type occurs only during braking. Lateral pull that occurs only during braking indicates a brake or suspension problem. Listed below are some of the causes of lateral pull.

A. Defective radial tire (one of the leading causes of pull)

B. Uneven tire pressure

C. Malfunction in the power steering control valve or power cylinder

D. Incorrect wheel alignment

E. Dragging brake

F. Broken or weak rear spring

VI. Hard steering simply means that a greater-than-normal effort is required to turn the steering wheel. Listed below are some of the causes of hard steering.

A. Steering gear adjustment too tight

B. Incorrect wheel alignment

C. Low tire pressure

D. Low or incorrect steering gear lubricant

E. Inadequate steering and/or suspension joint lubrication

VII. After the steering wheel is turned, it should be inclined to return to the straight-ahead position on its own. Poor steering return means that the steering wheel has difficulty returning to the straight-ahead position after a turn. Listed below are some of the causes of hard steering.

A. Steering gear adjusted too tightly

B. Incorrect wheel alignment (especially excessive positive caster)

C. Lack of steering linkage or suspension lubrication

D. Binding in steering column

VIII. Procedures for diagnosing wheel shimmy, vibration, vehicle wander and pull, and bearing noise during a road test

(CAUTION: Road test a vehicle only with the instructor's approval.)

A. Drive the vehicle on a variety of road surfaces to ensure that inadequate pavement is not causing the problem.

B. Drive the vehicle slowly (under 15 mph) in a straight line and note any wheel shimmy. Watch the steering wheel for any back-and-forth movement. Note any lateral shaking in the vehicle body.

C. While driving slowly (under 15 mph), listen for any wheel bearing noise. Steer from side to side while driving. Note any increase in noise. Note the wheel from which the noise comes.

D. Slowly accelerate to highway speed. Note any shimmy during acceleration.

E. Front-wheel-drive axle shaft misalignment may cause shimmy to occur at a certain speed.

F. During the road test, remember that a vibration may occur at any speed up to and including highway speed. Note what parts of the car seems to be vibrating. If the steering wheel, hood, dash, etc. are vibrating, the problem is likely caused by improper runout of the front wheel and tire or improper balance. If the vibration seems to move through the vehicle seat and body, the problem is likely in the rear wheel and tire.

G. Power train vibration problems can sometimes mislead the technician. The below procedure can be used to diagnose vibration more precisely.

1. Increase speed past the point at which the vibration occurs. Release the accelerator and carefully slip the transmission selector into neutral.

2. Allow the vehicle to coast until it reaches the speed at which the vibration occurs. If the vibration does not change, the cause is probably in the tires, wheels, or suspension.

   a. If the vibration stops or changes noticeably while the vehicle is coasting in neutral, the problem is likely in the drive line.

   b. If the vibration increases or persists with increasing speed, the problem could be in the tires, wheels, drums, or rotors.

   c. If the problem disappears as speed increases, the problem may involve tire and wheel runout.

H. Listen for wheel bearing noise at highway speed. At highway speed, defective wheel bearings will usually whine.

   (CAUTION: When driving at highway speed, do not turn the steering wheel rapidly from side to side as in the low-speed test.)

I. Following the procedure outlined below, determine if the vehicle wanders.

1. While driving straight, allow the steering wheel to move on its own.

   (CAUTION: Never completely let go of the steering wheel.)

2. If the vehicle wanders to one side, return the vehicle to its straight path. After relaxing the grip again, see if the vehicle wanders to the other side.

3. If the vehicle steering constantly has to be corrected to the right and left, the problem is wander.

4. If the car leads to the same side every time the steering is corrected, the problem is lateral pull.

   (**NOTE:** If wander is detected, drive the vehicle on different road surfaces. Some surfaces, such as those with a crown, may cause the vehicle to wander.)

J. Drive the vehicle on a flat, level surface and note any lateral pull. Lateral pull is characterized by a constant pull in the same direction. Carefully apply the brakes to see if the pull occurs only when braking.

K. During the road test, note any hard steering or poor steering return. Some vehicles are designed to steer harder than others; however, excessively hard steering should be obvious. The steering should always return to the straight-ahead position when coming out of a turn.

(**NOTE:** Though a road test usually cannot provide a final diagnosis, the information obtained during the test can help the technician gain a better idea of the nature of the problem. The symptoms noted during a road test can be compared to service manual diagnostic charts.)

(**NOTE:** The technician should always be aware that steering and suspension problems can be caused by relatively simple problems such as the following: excessive or uneven tire wear; incorrect air pressure in tires; radial tire pull; and lack of steering and suspension lubrication.)

AS1-L1-UXVII

MODULE: STEERING AND SUSPENSION SYSTEMS

DIAGNOSING VARIOUS STEERING, SUSPENSION, AND WHEEL ALIGNMENT PROBLEMS

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. What term is used to describe the rapid shaking of a vehicle as it is moving?

2. What term is used to describe the back and forth shaking of the vehicle's front wheels as it is moving?

3. What term is used to describe the condition that causes the driver to make constant steering corrections?

4. What term is used to describe greater-than-normal effort required to turn the steering wheel?

5. What term is used to describe the failure of the steering wheel to return to the straight-ahead position after a turn?

6. Name four relatively simple problems that can interfere with steering and suspension operation.

JS1-L1-UXVII

MODULE: STEERING AND SUSPENSION SYSTEMS

ROAD TESTING A VEHICLE FOR STEERING, SUSPENSION, AND WHEEL ALIGNMENT PROBLEMS

Equipment:

Pen
Notebook

Procedure:

(CAUTION: Always obtain instructor's approval before conducting a road test. Conduct the road test in an area with little or no traffic. Never exceed the legal speed limit during the road test. Always wear safety belts. An assistant should record all observations made during the road test. Do not attempt to drive and record results at the same time.)

1. Following the procedure outlined below, road test the vehicle for shimmy.

   a. Slowly drive the vehicle in a straight line and observe for shimmy.

   b. Slowly accelerate to highway speed while noting any shimmy.

   c. Have an assistant record the results of the shimmy test.

2. Following the procedure outlined below, road test the vehicle for vibration.

   a. Drive the vehicle at highway speed and note any vibrations.

   b. Vary speed and note if vibration increases, decreases, or changes in quality. If the vibration increases or persists with increasing speed, the problem may be imbalance of tires, wheels, drums or rotors. If the problem disappears with increasing speed, the problem may be tire and wheel runout.

   c. If vibration is noted, drive past the speed at which the vibration occurs, release the accelerator, and carefully slip the transmission selector into neutral. If the vibration stops, the problem is likely in the drive line.

   d. Coast down through the speed where the vibration occurs. If the vibration does not change, the cause is probably in the tires, wheels, or suspension. If the vibration does stop or change when the vehicle is coasting in neutral, the problem is likely in the drive line.

   e. Have an assistant record the results of the vibration test.

3. Following the procedure outlined below, road test the vehicle for wander.

   a. Relax hands on the steering wheel while driving straight.

   b. If the vehicle leads to one side, correct the steering and note if the vehicle leads to the other side. If the vehicle constantly has to be corrected to the right and left, the problem is wander.

      (**NOTE:** If the vehicle leads to the same side after every correction, the problem is lateral pull. The test for lateral pull is described below.)

   c. If wander or lateral pull is detected, drive the vehicle on different road surfaces to make sure that an irregular road surface is not causing the problem.

   d. Have an assistant record the results of the wander test.

4. Following the procedure outlined below, road test the vehicle for lateral pull.

   a. Drive the vehicle on a flat, level surface and note any lateral pull. Lateral pull is characterized by the vehicle leading in the same direction.

   b. If pull is detected, drive the vehicle on a variety of road surfaces to make sure the surface is not pulling the vehicle.

   c. Carefully apply the brakes to see if the pull occurs only when braking.

   d. Have an assistant record the results of the lateral pull test.

5. Following the procedure outlined below, road test the vehicle for excessive steering effort or poor steering return.

   a. Drive the vehicle on a flat, level surface and make several turns to both the left and the right.

   b. The effort required to steer the vehicle should not be excessive. Steering should be smooth. The steering should always return to the straight-ahead position when the vehicle is coming out of a turn.

   c. Have an assistant record the results of the steering effort test.

6. Following the procedure outlined below, road test the vehicle for wheel bearing noise.

   a. Drive the vehicle at a slow speed and steer it from side to side in order to load the wheel bearings on both sides of the vehicle. Listen for bearing noise.

   b. Note any increase in noise. Note the wheel from which the noise came. If bearing noise is detected, drive on different types of road surfaces to eliminate road surface conditions as a source of the noise.

c. Have an assistant record the results of the bearing noise test.

7. If any problems were detected during the road test, diagnose what the problem might be. Record the diagnosis.

   (**NOTE:** Use the diagnosis chart from the appropriate service manual to aid in diagnosis.)

MODULE: STEERING AND SUSPENSION SYSTEMS

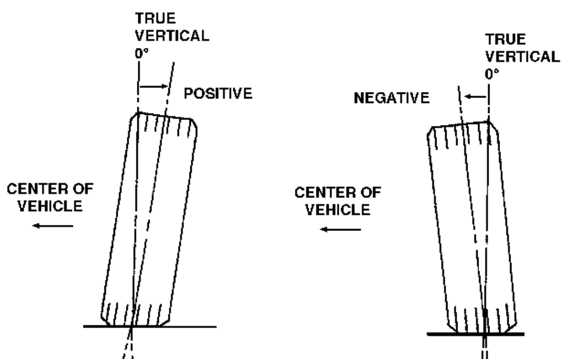
UNIT XVII: WHEEL ALIGNMENT AND STEERING AND SUSPENSION DIAGNOSIS

LESSON 2: PRINCIPLES OF WHEEL ALIGNMENT

I. Wheel alignment is the proper positioning of suspension and steering components. Wheel alignment prevents such problems as wandering and thus improves vehicle handling. Wheel alignment minimizes slipping and scuffing of the tires and thus reduces tire wear.

II. Wheel alignment angles

A. Camber is the inward or outward tilting of the wheels from a true vertical position. Positive camber refers to wheels that are tilted out at the top, causing the wheels to be further apart at the top than at the bottom. Negative camber refers to wheels that are tilted in at the top, causing the wheels to be closer at the top than at the bottom.



CAMBER

1. A vehicle is normally set with a slight positive camber (a slight outward tilt at the top). When the vehicle is loaded and rolling down the road, the wheels tend to move inward at the top and thus are brought into a vertical position. If the camber is set at zero (truly vertical), the top of the wheels would tilt inward (negative camber) as the vehicle moves.

2. The purposes of camber are listed below.

   a. Camber puts the point at which the tire contacts the road at or near the center of the tire tread.

   b. Camber provides for easy steering by allowing the vehicle weight to be carried by the inner wheel bearing and spindle assembly.

   c. Camber prevents tire wear.

   d. Camber can be used to compensate for road crown.

3. The effects of incorrect camber are listed below.

   a. Incorrect camber causes excessive wear on suspension components, particularly ball joints and wheel bearings.

   b. Incorrect camber causes excessive wear on one side of the tire tread.

   (**NOTE:** Excessive negative camber will cause wear on the inside of the tire tread. Excessive positive camber will cause wear on the outside of the tire tread.)

   c. Excessive unequal camber will cause the vehicle to pull to one side.

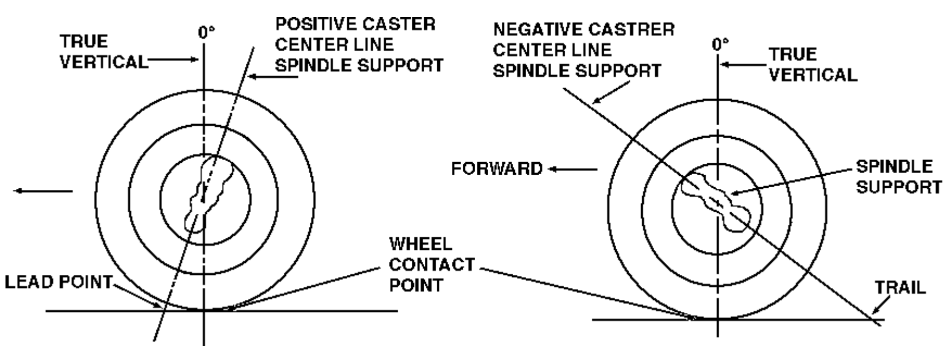
   (**NOTE:** The vehicle will pull toward the side with the most positive camber.)

   (**NOTE:** When possible unequal camber should be used to compensate for road crown. The spread between the camber readings between the two wheels should not exceed 1/2 of a degree.)

4. Though camber is adjustable on most vehicles, it is not adjustable on some front-wheel-drive vehicles.

5. Camber is measured by the number of degrees that the wheel centerline is tilted away from a truly vertical position.

B. Caster is the backward or forward tilt of the ball joints or strut from a truly vertical position. The backward tilt of the ball joints or strut is called positive caster while the forward tilt is called negative caster.



1. Caster has little to do with tire wear. However, caster allows for directional control of the vehicle by causing the front wheels to stay in the straight-ahead position or return to the straight-ahead position when coming out of a turn. Caster also can be used to offset road crown.

2. The effects of incorrect caster

   a. Too much positive caster or too little negative caster results in hard steering, shimmy, and the transfer of road shock to the driver.

b. Too little positive caster or too much negative caster results in high-speed instability and wander and weave.

c. Excessive unequal caster causes the vehicle to pull toward the side of the least positive or most negative caster.

(**NOTE:** Unequal caster can be used to offset road crown.)

(**NOTE:** In order to compensate for road crown, adjust the caster so the right side has slightly more positive caster with a maximum spread of 1/2 of a degree to 3/4 of a degree between the two sides.)

3. In order to maintain good steering return, vehicles with power steering need more positive caster than those with manual steering. Cars equipped with manual steering need less positive caster to ease steering effort.

4. Caster is measured by the number of degrees the ball joints or struts are tilted from a truly vertical position. Caster is usually adjustable on rear-wheel-drive vehicles but is seldom adjustable on front-wheel-drive vehicles.

C. Steering axis inclination (SAI) (also called ball joint or kingpin inclination)

1. SAI is a nonadjustable, built-in alignment angle. SAI is an angle that has much in common with caster. Like caster, SAI affects the handling characteristics of the vehicle.

2. The purposes of steering axis inclination are listed below.

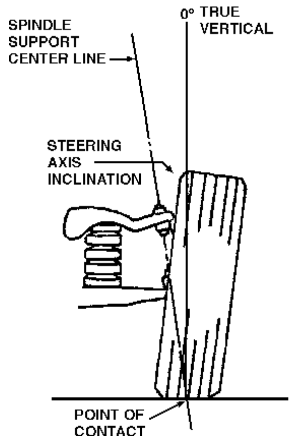
a. To distribute the weight of the vehicle more nearly under the road contact of the tire

b. To reduce the need for excessive camber

c. To provide a pivot point about which the wheel will turn and produce easy steering

d. To aid steering stability

3. Both SAI and caster are aligned with the tilt of the steering axis (the imaginary line through either the lower and upper ball joints or the lower ball joint and the top of the strut) as viewed from the side of the wheel. SAI is the tilt of the steering axis as viewed from the front of the vehicle.



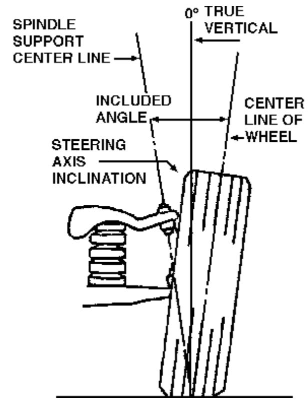
4. SAI is also similar to camber in that both angles align with the position of the wheels in relation to the chassis. Incorrect SAI can prevent the proper adjustment of camber. Incorrect SAI is also an indication of bent or damaged control arms, ball joints, steering knuckles, or vehicle frame.

5. The point at which the imaginary SAI line intersects the

   road surface affects vehicle steering effort and stability. If an imaginary centerline through the ball joints were vertical, it would intersect the road surface some distance inward of the point at which the tires contact the road. In this arrangement, the effort required to steer the wheel would be high because the full travel contact surface would turn sideways to the actual direction of travel. This would result in high turning effort and excessive tire wear. With increased SAI, the point of intersection is close to the center of the tire tread contact area. Since the tires turn about this center, there is less scrubbing action when the wheels are turned. Steering effort and tire wear are, therefore, reduced.

6. The distance between the point at which the SAI and the wheel centerline intersect the ground is called the scrub angle. If the pivot point is inside the tire centerline contact point, the pivot point is called the positive scrub radius. If the pivot point is outside the tire centerline contact point, the pivot point is then called the negative scrub radius. The amount and type of scrub radius can only be determined by the vehicle manufacturer.

D. Included angle is the camber angle combined with the SAI angle. The included angle determines the point of intersection of the wheel and ball joint centerlines.



E. Toe

1. Toe is a measurement of the difference in distance between the front extension of the tires to the rear extension of the tires. The purpose of toe is to achieve directional stability while the vehicle is moving. Toe is an adjustable angle and a tire wear angle. Toe is measured in fractions of inches, millimeters, or degrees.

2. The condition called "toe in" occurs when the distance between the front of the wheels is less than the distance between the back of the wheels. The condition called "toe out" occurs when the distance at the front of the wheels is greater than at the back of the wheels.

3. Rear-wheel-drive vehicles are usually set slightly toe in because the force created as the vehicle rolls forward tends to force the front of the tires outward. Many front-wheel-drive vehicles are set with a slight toe out because the tires tend to move together at the front as the vehicle rolls forward.

4. The effects of incorrect toe

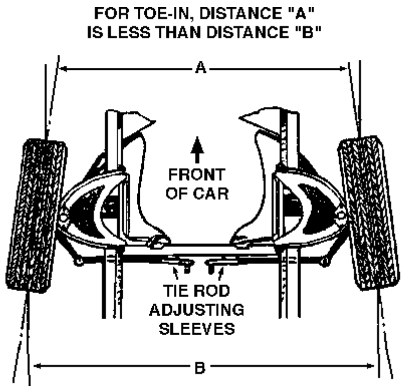
   a. Excessive toe causes feathered tire wear.

   b. Excessive toe causes tires to squeal during cornering.

   c. Too much toe in causes either feathered wear or wear to the outside of the tire located on the right axle.

   d. Too much toe out causes either feathered wear or wear to the inside of the tire located on the left axle.

   (**NOTE:** A vehicle set with zero toe will wander.)

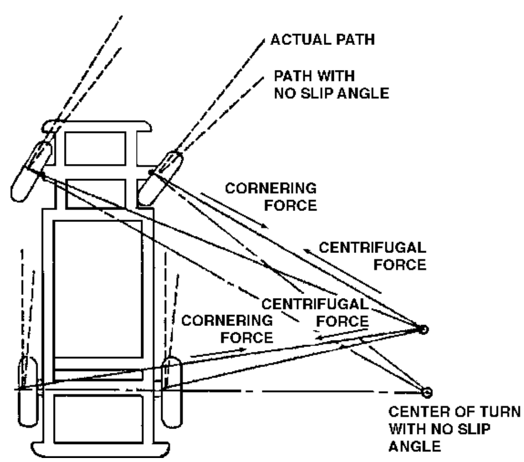


F. Toe out on turns (also called front-wheel turning angle or turning radius)

1. Toe-out on turns is the difference in angles between the two front wheels and the vehicle frame during a turn. Toe out on turns is usually a non-adjustable angle that controls the tracking of the front wheels during turns. Toe out on turns is used to minimize tire wear while cornering.

2. The inner wheel follows a smaller radius than the outer wheel when the vehicle is rounding a curve. The inner wheel axle, therefore, must be at a sharper angle to the vehicle frame than the outer wheel axle. The inner wheel is toed out a greater distance. Toe out on turns is achieved by the inward angle of the steering knuckle arms at the point where they attach to the steering linkage.

3. Toe out on turns is adjustable on some vehicles; however, incorrect toe out on turns often indicates that a suspension component is bent or broken.



4. If the toe out on turns is incorrect, the tires will wear excessively during cornering. This excessive wear will be evidenced by a squealing of the tires during cornering. The squeal will occur even at low speeds.

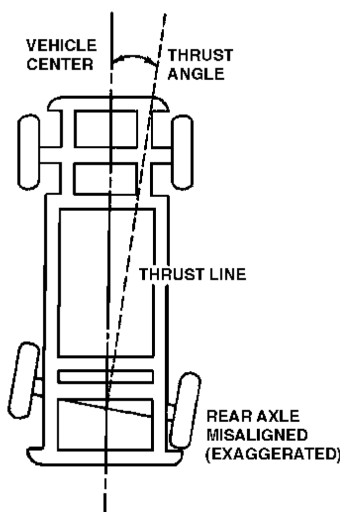
G. Thrust angle

1. Thrust angle (line) is the direction that the vehicle's rear wheels would travel if unaffected by the front wheels. The thrust angle determines the vehicle's tracking. An incorrect thrust angle will cause the vehicle to appear to be running (tracking) sideways down the road. This sideways movement is called "dog tracking."

2. If there is no misalignment, the thrust angle (line) should be the same as the vehicle centerline. The centerline is an imaginary line through the center of the vehicle. (The vehicle is thought of as being constructed upon the centerline.)

3. The vehicle frame should be parallel to the centerline. The angles formed by the axles intersecting the vehicle centerline should be 90-degree angles. If the rear wheels are square with each other and the rear axle is at right angles with the centerline, the correct thrust angle will be zero.

4. The angle formed between the vehicle centerline and the thrust line is called the thrust angle. Incorrect thrust angle will cause the vehicle to pull to one side. Incorrect thrust angle can also affect directional stability and braking control.



5. The thrust angle is not adjustable on most rear-wheel-drive vehicles. Improper thrust angle is usually caused by broken spring tie bolts or broken spring leaves causing the axle assembly to shift. Also, frame damage resulting from an accident could be the cause. On front-wheel-drive vehicles, incorrect thrust angle is more common. The rear toe and camber is adjustable on many of these vehicles. Adjustable rear toe and camber allows for easier correction of the problem if spring, axle, or frame damage is not the cause.

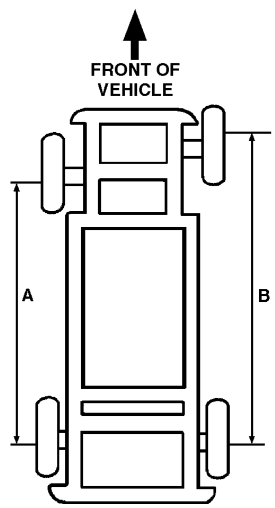
6. On front-wheel-drive vehicles, improper thrust angles could be corrected by aligning the rear wheels.

   (**NOTE:** Newer wheel aligning equipment capable of measuring alignment at all four wheels can detect improper thrust angle.)

H. Setback

1. Setback is a condition in which one of the vehicle's wheels sets further toward the rear of the vehicle than the wheel on the other side. Excessive setback is usually the result of a frontal impact that pushes one wheel toward the rear of the vehicle.

2. Setback can be measured on most modern alignment equipment. Most vehicles can tolerate a slight amount of setback without any problems. Because setback is not adjustable, excessive setback is corrected by replacing components or straightening the vehicle frame.



I. Before making any alignment adjustments, the vehicle's ride height should be checked and corrected. If the ride height is incorrect, the other wheel alignment angles will be thrown off. Incorrect ride height can be adjusted on some torsion bar suspension systems, but otherwise springs or other suspension parts must be replaced to correct ride height.

(**NOTE:** See Unit IX of this module for details on vehicle ride height.)

AS1-L2-UXVII

MODULE: STEERING AND SUSPENSION SYSTEMS

WHEEL ALIGNMENT PRINCIPLES

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. What term is used to describe the inward or outward tilt of the top of the front wheels?

2. What term is used to describe the rearward or forward tilt of the ball joints or strut?

3. What term is used to describe the difference in distance between the front of the tires and the rear of the tires?

4. What measurement should be taken before any alignment adjustment is made?

5. What is the result of excessive thrust angle?

6. What is the effect of incorrect camber?

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XVII: WHEEL ALIGNMENT AND STEERING AND SUSPENSION DIAGNOSIS

LESSON 3: MEASURING AND CORRECTING WHEEL ALIGNMENT

I. Wheel alignment equipment

(**NOTE:** The design and complexity of wheel alignment equipment can vary greatly. The equipment may consist of either simple gauges or complex electronic machines.)

A. Some electronic wheel alignment equipment has a sensor at each wheel. These sensors send signals to a panel or screen. The screen shows the misalignment and helps guide the technician through the adjustment procedures. The technician enters the alignment specifications into the machine. The technician can then print out a sheet showing alignment specifications, actual readings before alignment, and readings taken after alignment is completed.

B. Turntables are sometimes used during wheel alignment to allow the front wheels to turn easily during the procedure. The turntables are marked in degrees. The vehicle is placed on the turntables with the wheels straight ahead. The turntables are then set on the zero degree mark. The wheels are then turned to check caster and toe out on turns.

C. Wheel alignment may be performed by placing the vehicle on a level floor with the front wheels resting on turntables. (The vehicle is not raised.) For this procedure, it is very important that the vehicle rests on a level surface. If wheel alignments are performed in this manner, it may be difficult to reach adjustment devices.

D. The most convenient way of doing wheel alignment is through the use of a special hoist equipped with turntables. The hoist raises the vehicle on a level surface and allows the technician access to the adjustments under the vehicle.

(**NOTE:** Many special tools are designed to assist the technician in adjusting wheel alignment.)

II. Procedures for making pre-alignment checks

(**NOTE:** The procedure below involves tasks that should be done prior to measuring or adjusting alignment.)

A. Make sure tires are at proper inflation pressure.

B. Make sure all tires are the same size.

C. If necessary, check and adjust wheel bearing adjustment.

D. Inspect for loose, worn, or damaged steering and front and rear suspension components.

E. Test ball joint condition.

F. Check for wheel and tire assembly runout.

G. Check and adjust steering gear adjustment.

H. Check for excessive vehicle loads. Remove any excessive loads, if found.

I. Check and correct vehicle ride height.

J. Remove any dirt and mud from the wheels, tires, or suspensions.

K. Check manufacturer's alignment procedures for unique instructions. Some manufacturers require that the gas tank be full during alignment. Others require that weight be added to the car to simulate passenger weight.

III. Interrelation of alignment angles

A. The various alignment angles are interrelated; therefore, alignment angles will have to be adjusted in a specific order. The manufacturers of alignment equipment usually provide a manual which gives the order for checking and adjusting the various angles.

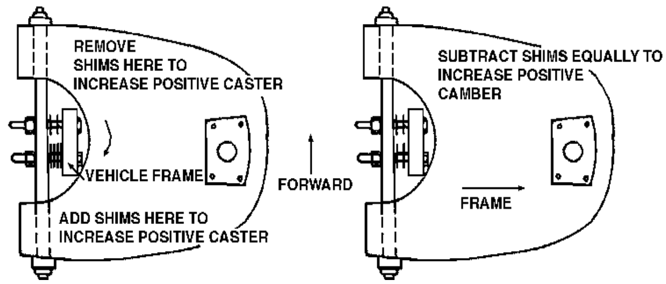
B. Front wheel angles are usually checked in the following order: 1) camber, 2) caster, 3) toe, 4) SAI, and 5) toe-out on turns. This order ensures that an angle that has been properly set is not changed. No matter what the order of angle adjustment is, always recheck the other angles after changing one.

(**NOTE:** Due to the variations in procedures for various types of alignment equipment, this unit will deal only with procedures for changing adjustable angles. See the equipment manufacturer's instruction manual for directions on using a particular alignment machine.)

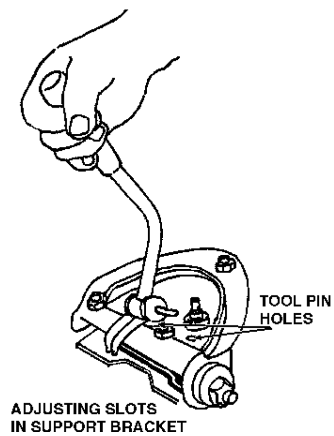
(**NOTE:** Never correct alignment by heating or bending steering or suspension components. If corrections cannot be made through normal adjustment procedures, the defective parts must be replaced.)

IV. Procedures for adjusting front-wheel camber

A. Depending on the suspension design, a variety of methods must be used to adjust front-wheel camber. One common adjustment method involves adding or removing shims from the upper control arm shaft mounting points. Moving an equal number of shims on both the front and rear of the arm changes camber without affecting caster.



B. Slotted holes at the upper control arm mounting points can also be used to adjust front-wheel camber. Moving both the front and rear of the arm an equal distance in the same direction will change camber without affecting caster.



C. Vehicles that have the spring on the upper control arm usually have an eccentric cam adjustment, which allows for the adjustment of front-wheel camber.

(**NOTE:** Eccentric cam adjustment or slotted hole adjustment is used at the lower attaching point of some MacPherson strut vehicles.)

D. Eccentric cam adjustment is also found at the upper control arms of some vehicles with short and long arm suspension. When the cam adjustment is moved an equal distance to the front and rear, camber will be changed without affecting caster.

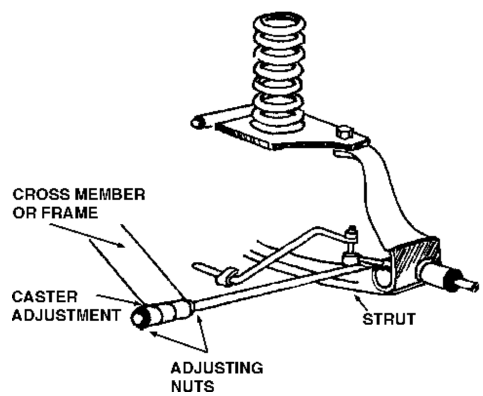
V. Procedures for adjusting front-wheel caster

A. Many of the procedures for adjusting camber apply to adjusting caster. When changing caster or camber, be careful to change only those which are not within specifications.

B. As in front-wheel camber adjustment, front-wheel caster can be adjusted by adding or removing shims at one end of the upper control arm. However, adding or removing shims will also change camber. Removing shims from one end and adding the same shims to the other end should change caster without affecting camber.

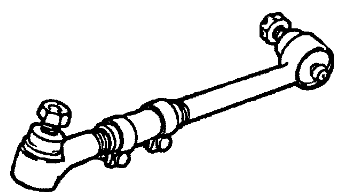
C. Slotted adjustment and eccentric cam adjustment on the upper control arm allows for adjustment of front-wheel caster as well as front-wheel camber.

D. Vehicles with the spring on the upper control arm as well as some MacPherson strut vehicles are equipped with adjustable strut rods to correct caster. Changing the strut rod adjustment moves the lower control arm forward or backward to change caster.



VI. Procedures for adjusting front-wheel toe

A. Front-wheel toe is changed by using the adjusting sleeve to increase or decrease the tie rod length. The procedure is outlined below.



1. Center the steering wheel with the front wheels pointing straight ahead.

   (**NOTE:** If the vehicle is equipped with power steering, start the engine and move the steering wheel back and forth several times to center the steering. Turn off the engine and lock the steering wheel in the straight-ahead position with a steering wheel locking clamp. A few manufacturers specify that the engine be kept running while the toe is being adjusted.)

2. Loosen the tie rod clamp bolts and adjust toe.

   (**NOTE:** Key the tie rods about the same length.)

3. Tighten the clamp bolts to specification. Make sure tie rods are centered in their bowls. Do not allow the gap in the sleeve clamp to line up with the gap in the sleeve. Position clamps as instructed by the manufacturer.

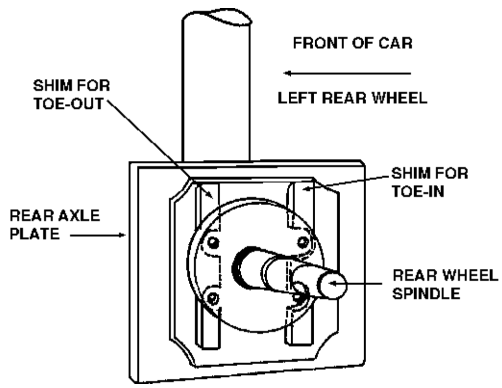
B. Other methods for adjusting toe involve the use of either an optical system or a computer-assisted toe adjuster. Both of these machines adjust toe in relation to the vehicle's centerline and, therefore, allow for the most accurate toe adjustment.

VII. Procedures for rear-wheel alignment

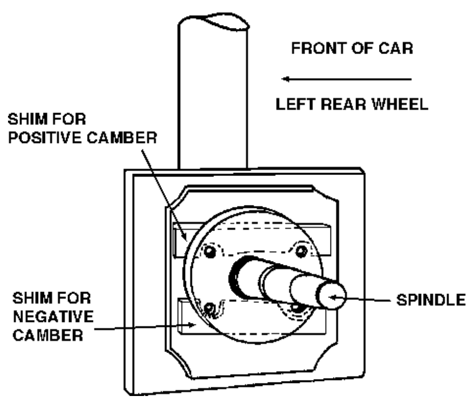
A. Rear-wheel alignment can be performed on a machine designed to align all four wheels at once. Rear-wheel alignment can also be performed on a two-wheel alignment rack. The vehicle is simply backed onto the two-wheel alignment rack.

B. Camber and toe are adjustable on the rear wheels of many front-wheel-drive vehicles. One common method for adjusting camber and toe on the rear wheels is done by removing the wheel spindle and installing selective shims between the spindle and axle.

1. Installing shims in the front or rear of the spindle changes toe.



2. Installing shims on the upper or lower side of the spindle changes the camber.



C. Eccentric cams, which are attached to the interconnecting points of the lower control arms, also provide a means for adjusting toe on the rear wheels of front-wheel-drive vehicles. The cams adjust the length of the control arms to change toe.

VIII. Four-wheel alignment

A. Four-wheel alignment ensures that all four wheels are parallel to each other and perpendicular to the imaginary centerline of the vehicle. In past years, vehicles with unibodies had enough front alignment adjustment to cover imperfections in the rear axle. Today's vehicles do not have adequate adjustment.

B. Four-wheel alignment provides for less rolling resistance, better fuel economy, and longer tire life. Four-wheel alignment also causes the vehicle to drive and track straight ahead when the steering wheel is centered.

C. Four-wheel alignment can be performed either on two-wheel alignment equipment or four-wheel equipment.

(**NOTE:** If the technician uses two-wheel alignment equipment to perform a four-wheel alignment, he or she will have to take extra steps to ensure that the vehicle centerline is correct. These centerline checks are usually done automatically by four-wheel alignment equipment.)

(**NOTE:** If the technician uses two-wheel alignment equipment to perform a four-wheel alignment, he or she must align the rear wheels first by backing the vehicle onto the equipment.)

D. Procedure for performing a four-wheel alignment

(**NOTE:** The below procedure is general and will not apply to all alignment equipment or vehicles. Refer to the procedure provided by the manufacturers of the alignment equipment or the proper vehicle service manual for more specific procedures.)

1. Perform all pre-alignment procedures.

2. Set the rear camber, if necessary.

3. Set the rear toe, if necessary.

4. Set the caster and camber on one of the vehicle's front sides.

5. Set the caster and camber on the other front side of the vehicle.

6. Set the front toe.

JS1-L3-UXVII

MODULE: STEERING AND SUSPENSION SYSTEMS

MEASURING AND CORRECTING FRONT-WHEEL ALIGNMENT

Equipment:

Alignment machine
Hand tools
Special tools as needed
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

   (**NOTE:** If the vehicle being serviced requires a four-wheel alignment, adjust the rear wheels first.)

2. Place the vehicle securely on safety stands or safely lift it with a hoist.

3. Perform a pre-alignment check of the vehicle. Use the checklist below to indicate if an item is "OK" or "NOT OK."

Tire pressure	OK ____	NOT OK ____
Wheel bearing adjustment	OK ____	NOT OK ____
Condition of steering and suspension components	OK ____	NOT OK ____
Tire and wheel assembly runout	OK ____	NOT OK ____
Steering gear adjustment	OK ____	NOT OK ____
Excessive vehicle load	OK ____	NOT OK ____
Ball joint condition	OK ____	NOT OK ____

   If any item in the above list is "NOT OK," describe the problem and recommend repair procedures in the space below.

(**NOTE:** If worn or loose parts are found, they must be replaced to ensure an accurate alignment. Inform the instructor if worn parts are discovered during the pre-alignment inspection.)

4. Using a service manual or other information source, locate a procedure for outlining the proper sequence for measuring front-wheel alignment angles. List all angles that the alignment equipment is capable of measuring. Record the specifications for each angle. Also record the vehicle's ride height specifications. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Measure vehicle ride height and compare it to the specifications recorded in the above procedure.

Is vehicle at its proper ride height? Yes _____ No _____

(**NOTE:** Incorrect ride height will result in incorrect alignment. If ride height is incorrect, consult the instructor before continuing.)

5. Following the sequence developed in item 4 of this job sheet, measure camber and caster. Record the measurements.

	Left	Right
Camber		
Caster		

6. Using a service manual or other information source, locate a procedure for adjusting fronw-wheel caster. Include any special tools required. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

(**NOTE:** Make sure alignment adjustments are made in the sequence prescribed by the manufacturer. Making adjustments in the wrong sequence can result in improper alignment.)

Following the procedure, adjust front-wheel caster to specifications. Record observations.

7. Using a service manual or other information source, locate a procedure for adjusting front-wheel camber. List any special tools required. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, adjust front-wheel camber to specifications. Record observations.

8. Measure toe and record measurements.

____

9. Following the procedure developed in item 5 of AS1-L3-UXVII, adjust front-wheel toe to specifications.

10. Using a service manual or other information source, locate a procedure for adjusting front=wheel toe. List any special tools required. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

(**NOTE:** The correction of one adjustment angle may affect some other adjustment angles. Consider the proper adjustment sequence when making any adjustments.)

Following the procedure, adjust front-wheel camber to specifications. Record observations.

11. Record any angles that could not be adjusted to specifications. Indicate what problem may be preventing proper adjustment.

JS2-L3-UXVII

MODULE: STEERING AND SUSPENSION SYSTEMS

MEASURING AND CORRECTING REAR-WHEEL ALIGNMENT

Equipment:

Alignment machine
Hand tools
Special tools as needed
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

   (**NOTE:** If the vehicle being serviced requires a four-wheel alignment, adjust the rear wheels first.)

2. Place the vehicle securely on safety stands or safely lift it with a hoist.

3. Perform a pre-alignment check of the vehicle. Use the checklist below to indicate if an item is "OK" or "NOT OK."

   Tire pressure OK ____NOT OK ____

   Wheel bearing adjustment OK ____NOT OK ____

   Condition of suspension components OK ____NOT OK ____

   Tire and wheel assembly runout OK ____NOT OK ____

   Steering gear adjustment OK ____NOT OK ____

   Vehicle load OK ____NOT OK ____

   If any item in the above list is "NOT OK," describe the problem and recommend repair procedures in the space below.

(**NOTE:** If worn or loose parts are found, they must be replaced to ensure an accurate alignment. Inform the instructor if worn parts are discovered during the pre-alignment inspection.)

4. Using a service manual or other information source, locate a procedure for measuring rear-wheel alignment angles. Record the specifications for each angle. Also record the vehicle's ride height. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Measure vehicle ride height and compare it to the specifications from the avove procedure. Is vehicle at its proper ride height?

Yes _____ No _____

(**NOTE:** Incorrect ride height will result in incorrect alignment. If ride height is incorrect, consult the instructor before continuing.)

5. Following the sequence developed in item 4 of this job sheet, measure all rear-wheel alignment angles. Record the measurements.

	Left	Right
Camber		
Caster		

6. Using a service manual or other information source, locate a procedure for adjusting rear-wheel camber. List any special tools required. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, adjust rear-wheel camber to specifications. Record observations.

(**NOTE:** Make sure alignment adjustments are made in the sequence prescribed by the manufacturer. Making adjustments in the wrong sequence can result in improper alignment.)

7. Using a service manual or other information source, locate a procedure for adjusting rear-wheel toe List any special tools required. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, adjust rear-wheel toe to specifications. Record observations.

8. Check vehicle thrust angle if the alignment equipment allows for it. Record results.

9. Recheck all angles. Correct any angles that still do not meet specifications.

(**NOTE: The correction of one adjustment angle may affect some other adjustment angles. Consider the proper adjustment sequence when making any adjustments.)**

10. Record any angles that could not be adjusted to specifications.   Indicate what problem may be preventing proper adjustment.