1. List the six functions of suspension components.
2. List the six major groups of components that require inspection.
3. Explain the inspection methods for the individual suspension components.
The suspension system is made up of the springs, shock absorbers, control arms, ball joints, and bushings. They are responsible for six closely related major functions.

- Maintaining contact between the tire and the road.
- Supporting the weight and load of the vehicle.
- Absorbing and damping road shock.
- Maintaining proper alignment between the body and wheels.
- Transmitting the forces of acceleration, braking, and cornering to the body and passenger compartment.
- The front suspension must also pivot to allow for vehicle steering.
The lower control arm is longer than the upper control arm. This design causes each arm to follow a separate travel path as the suspension compresses and rebounds. Suspension movement causes the wheel to tilt, preventing a change in track width. This maintains maximum tread contact with the road through all motions of the suspension and improves vehicle handling. Double wishbone suspension systems provide excellent ride quality, since road shock has a long travel path and is well insulated by bushings.
Compressing the dual link, independent strut suspension causes the wheel hub to follow an arc around the forward mount of the strut rod. The strut rod allows the wheels to move up and down without pivoting in or out, preventing changes in toe settings.
On double wishbone suspension, the location of the lower suspension arms controls the amount of track change when the suspension is under compression. As the suspension is compressed, negative camber is added which improves tread contact and vehicle handling. Compliance steer, pivoting of the rear wheels while cornering, also improves cornering performance. When the vehicle enters a corner, the number one suspension arm inboard bushing deflects causing the outer wheel to pivot inward toward the direction of the turn.

On torsion beam suspension, the toe-correct Function uses the longitudinal and lateral forces during cornering to deform the bushings in the trailing arms. For example on a right turn, the right side trailing arm moves forward and the left trailing arm moves rearward, creating a tendency for the left wheel to toe-out. With Toe-correct bushings installed, cornering forces are applied to move the left trailing arm towards a toe-in direction.
Six major components or groups of components are used to construct the suspension systems for Toyota vehicles.

1. Springs
2. Shock Absorbers and Struts
3. Stabilizers or Anti-Roll Bars
4. Control Arms, Strut Rods, Bushings, and Links
5. Ball Joints
6. Spindle or Axle Hub Assemblies
Springs are the flexible component of a suspension system. A vehicle's springs serve three basic purposes:
1. Support the weight or load of the vehicle
2. Absorb road shock
3. Establish the ride height of the vehicle

Four types of springs are used on Toyota vehicles:

- Coil springs
- Leaf spring
- Torsion bars
- Pneumatic cylinders
Coil Springs are formed by winding spring steel wire into coils. The spring rate is determined by the length and diameter of the steel. Long or thin pieces of steel have a lower spring rate than short or thick pieces. **A progressive spring rate** can be used to vary the rate of spring compression. This is accomplished by changing the spacing or diameter of the coils in the spring.
Spring sag describes a reduction in the tension or elasticity of a spring. Weak springs result in lower ride height, reduced suspension travel, accelerated and irregular tire wear, suspension bottoming, and reduced ride quality. The best inspection for identifying a sagging spring condition is ride height measurement.

When measuring ride height follow these precautions:
1. Use only measurement points specified in the Repair Manual.
2. Correct the tire pressure and verify tire size is equivalent to OEM before measuring.
3. The vehicle must be on a level surface.
4. Remove excess weight from the passenger compartment and trunk.
5. Bounce the suspension several times before taking any measurements.
6. When measuring, visually inspect the rebound bumpers for excessive wear and the control arms or axle for shiny spots that would indicate the suspension is riding on its stops.

A low value on one side of the vehicle can be caused by either the front or rear springs. To determine which springs are sagging, raise the vehicle at the center of the front or rear axle until the tires just leave the ground. If the ride height on the opposite end is now correct, the springs on the raised axle need to be replaced. Always replace both springs on an axle, do not replace just one.
Springs of all types should be inspected for any sign of physical damage. Significant nicks or damage to the exterior surfaces of spring steel form stress risers. These stress risers cause the steel to work-harden at the point of damage and can eventually lead to breakage. Springs with large cuts or notches should be replaced.
Torsion bars are long, straight steel rods that are attached to the vehicle frame at one end and to a control arm at the other. Compression of the suspension causes the torsion bar to twist. This twisting force provides the spring action. Torsion bars are directional and should only be installed on the correct side of the vehicle. An R or L is usually stamped into the torsion bar indicating the correct mounting location. Changing the preload or twist on the torsion bar with the adjustment screw can change vehicle ride height.

Pneumatic cylinders take the place of springs or torsion bars on some Toyota vehicles. They may be attached to the strut/shock absorber or between the frame and the axle assembly. The pneumatic cylinder uses compressed air to raise or lower the height of the vehicle.
Leaf Springs

Leaf springs are made of a number of curved bands of spring steel, called "leaves", stacked together. This stack is fastened together at the center with a bolt or a rivet and also held at several places with clips to keep the leaves from slipping out of place. Additionally leaf springs are attached to the frame & used to locate the axle assembly. Multi-leaf springs are most often used on the rear of trucks as they are capable of handling greater loads.

Tundra Rear Leaf Springs

While the vehicle is cornering, the leaf springs are designed so that the tire turns in the direction of understeer to improve driveability.

SERVICE TIP

The U-bolt seat has a right- and left-side directionality. Be sure to observe the proper tightening sequence and torque.
After being compressed an unregulated spring will oscillate many times. To control this, a shock absorber is mounted between the frame or unibody structure and a movable suspension component such as a control arm. In addition to damping spring oscillations, shock absorbers maintain tire tread contact with the road and limit the suspension travel.
A shock absorber is an oil filled cylinder. Inside the cylinder is a piston containing holes or valves that move through fluid or a combination of fluid and gas. The resistance to travel the piston encounters provides the damping action of the shock absorber.

The simplest shock absorber design found on Toyota vehicles is the conventional hydraulic, double tube shock absorber. This design consists of two steel tubes that form an inner pressure chamber and an outer reservoir. Fluid movement between the pressure chamber and reservoir is controlled by valves in the piston and the base.

The sizes of the piston holes determine the damping force, or how quickly the shock absorber can stabilize the suspension movement. Small piston holes increase the damping force and large holes decrease damping force.

Shock extension provides a higher damping rate than shock compression. When the suspension is compressed, the fluid between the piston and base valve is under the highest pressure. The oil is forced through the valves in the piston and the base valve. When the shock is extended, the area above the piston is under the greatest pressure and fluid flows through the piston.

Rapid movements of the shock absorber piston inside the pressure chamber create air pockets. To prevent cavitation and aeration of the oil, which causes abnormal noises and internal pressure fluctuations, many shock absorbers are charged with nitrogen gas.
MacPherson Strut combine the role of the spring, shock absorber, and upper suspension pivot point into one unit. At the core of the strut assembly is a shock absorber, similar to a gas filled shock absorber.

Struts use a piston rod much larger than used in a conventional shock absorber. Since the struts serve to locate the suspension, they need a large piston rod to absorb high lateral loads. Lateral load on the strut is further minimized by integrating the spring seat into the strut body and offsetting it from the piston rod. The upper spring seat is the upper strut mount. The upper strut mount contains a strut bearing and allows the strut body to pivot with the front wheels. This bearing is not needed in rear suspension applications.

**NOTE**

The condition of the upper spring seat or strut bearing may be the source of strut assembly noise. Refer to TSB SU002-04 and others related to strut bearing noise.
While shocks and struts do not have regular replacement intervals, they should be replaced when they exhibit any of the following conditions:

- Insufficient damping – ‘jounce’ or road test
- Oil leakage – visual inspection (See TSB SU007-06 for illustrations of acceptable seepage compared to unacceptable leakage.)
- Physical damage including impact damage, broken mounts, bushing failure – visual inspection
- Noise or signs of other internal malfunctions - road test
- Upper strut bearing - free play check

After a thorough visual inspection, the best test for shocks or struts is a road test over a fairly rough road surface. **If the vehicle’s suspension bottoms or oscillates excessively following a mild bump, the shock absorbers may need to be replaced.**

Other symptoms of worn shocks and struts include **excessive brake dive or squat on acceleration, body sway, and abnormal tire wear.** Do not immediately condemn shocks or struts for abnormal tire wear alone. Several other factors can create the cupping type wear often attributed to shock problems. Replacement of the shocks or struts will not resolve these other conditions.

**Inspect the upper strut bearing** by raising the vehicle by the unibody lift points and rock the tire laterally; also lift directly under the tire with a prybar. Perceptible play in either direction (lateral or vertical) may indicate a faulty bearing.
Gas-Filled Shock Disposal

Drill a hole in the location shown in the Repair Manual to discharge the gas inside. (The gas is colorless, odorless, and non-poisonous.)

Front Strut
For Standard Type:

Rear Shock Absorber
For Standard Type:

For Off-Road Package:
Gas Area Oil Area

Gas Area Oil Area

(examples from 2008 Tundra)

Gas-Filled Shock Disposal

When disposing of gas filled shocks, struts or reservoirs:

- If necessary, fully extend the shock absorber rod (in most cases, pressure within gas gas-filled shock absorbers constantly pushes the piston rod out & extends the rod).

- Using a drill, make a hole in the cylinder as shown in the illustration to discharge the gas inside. CAUTION: The discharged gas is harmless, but be careful of chips which may fly up when drilling. Always refer to the repair manual for the appropriate drill size & location as different types of shocks have different dimensions where they must to be drilled to relieve gas pressure.

- In the case of the X-REAS center control absorber, remove the flare nut & then drain suspension fluid before disposal.

SERVICE TIP

Front struts that can be disassembled (for a cartridge insert) are handled differently than those that cannot be dis-assembled. This type can be readily identified by a ring nut at the top of the body that can be removed.
**Stabilizer Bars**
When a vehicle turns, the inside wheel tries to lift up and forces the outside wheel down and outward. A stabilizer bar is used to control this action. The stabilizer bar, or anti-roll bar, is mounted transversely to the body, between the right and left suspension arms. Stabilizer bars are used in front and rear suspensions. They use the same operating principles as a torsion bar. During a turn the stabilizer bar twists, like a torsion bar, resisting body roll which maintains a greater vehicle load on the inside wheel.

**Stabilizer Bar Inspection**
The primary inspection item for stabilizer bars is the condition of the bushings and links. Inspect for deterioration, damage, and excessive play. Many hard to find suspension noises can be traced to the stabilizer bar bushings. Remember when installing new bushings, torque the fasteners with the vehicle at its normal ride height. Also stabilizer bar links should be equal lengths on both sides of the car to prevent preloading the bar.
The function of the control arms, links, and strut rods is to locate the wheel hub or steering knuckle. The suspension geometry is determined by the placement of these components. This establishes the vehicle’s overall handling traits. These components contain rubber bushings that allow the suspension to move and absorb minor road shocks and vibrations. Bushings with different flexibility are used to achieve certain ride quality or vehicle handling characteristics.

Inspection of control arms, bushings, and links primarily involves visually checking for physical damage, distortion, and rubber deterioration. Worn or damaged bushings may cause changes in alignment geometry that result in abnormal or irregular tire wear. Clunking or thumping noises that can be heard during acceleration or braking often indicate worn bushings as well.

When installing components with bushings, such as control arms and stabilizer bars, torque the components with the suspension at normal ride height.

NOTE

Most rubber bushings used on Toyota vehicles do not require lubrication. Applying petroleum lubricants to these bushings accelerates their deterioration.
Excessive ball joint free play or wear can lead to abnormal/irregular tire wear, hard steering, excessive vibration, and poor directional stability. Three different inspections are used to determine the condition of ball joints.

- Visual inspection
- Unloaded free play or vertical play
- Rotational torque

Carefully check the grease boot for damage or leakage. Torn boots allow the grease to escape providing a path for water, dirt, and road salt to get into the joint. Also, inspect the control arm and steering knuckle for any cracks or other signs of physical damage.
Load carrying and non-load carrying (follower) are the two classifications of ball joints. Load carrying ball joints transfer the weight of the vehicle through the suspension.

The load placed on a load carrying ball joint is grouped into two categories: tension or compression. A tension loading force tries to pull the joint apart. A compression loading force tries to press the ball into the socket.

Non-load carrying ball joints are primarily responsible for positioning the steering knuckle. They do not carry the vehicle’s weight. The only stress applied to the non-load carrying ball joint is the lateral and longitudinal loads from the steering knuckle. Sometimes preload springs are used to maintain zero free play inside this ball joint. Most Toyota ball joints are sealed units filled with high damping grease and are not serviceable.

To identify the load carrying ball joint, trace the path of the weight of the vehicle from the road surface to the suspension spring.

a. The upper ball joint is the load carrying ball joint if the spring is connected to the upper control arm.

b. The lower ball joint is the load carrying joint if the spring is connected to the lower control arm.

c. There is no load carrying ball joint in a MacPherson strut suspension. The lower ball joint is a non-load carrying joint, positioning the steering knuckle.
Regardless of vehicle model or type of ball joint, a visual inspection should be performed anytime the vehicle is serviced. When further inspection is necessary, the Repair Manual identifies which inspection method should be used to verify the internal condition of the ball joints on a particular vehicle.

Pay particular attention to load carrying joints as they will generally exhibit more wear than follower joints. Also note that if one load carrying joint is identified as faulty, the matching joint on the other side of the vehicle should be carefully inspected as it is likely to be worn out as well.
The recommended ball joint inspection method for many early vehicles is a measurement of joint free play or clearance. Most load carrying joints on these models allow a minimal amount of vertical free play. As the joint wears, the clearance increases and may become excessive.

Inspection of free play requires a load carrying ball joint be unloaded. The amount of play between the steering knuckle and control arm is then measured with a dial indicator. To unload the joint, the vehicle is raised by either the lower control arm or the frame. Placement of the jack depends upon the location of the spring and load carrying joint.

When performing this check, unload both load carrying joints on the vehicle at the same time to prevent the stabilizer bar from twisting and preloading the joint. A dial indicator should be placed between the suspension arm and steering knuckle to measure the amount of free play.

Be sure to refer to the Repair Manual for the vehicle you are inspecting to find specifications and the exact procedure. Most models require the front wheels be pointed straight ahead and some models require the brake pedal to be depressed.
MacPherson strut suspensions do not have a load carrying joint. The lower ball joint used with this type of suspension is a follower joint. The upper strut bearing bears the most load and can be quickly checked for excessive play by raising the vehicle from the frame or unibody. After removing the load from the bearing, rock the tire laterally and watch for excessive movement in the upper strut bearing assembly. Perceptible play may indicate a worn strut bearing or worn lower ball joint. This is a quick check only, be sure to consult the Repair Manual for specific procedures.

When performing the unloaded free play check, keep the suspension as close to its normal operating position as possible. This will help ensure you are measuring with the ball joint at its most worn position.
The ball joint inspection method recommended for most late model Toyota vehicles is a rotational torque check. Many current model ball joints are designed with a preload spring. These designs are more difficult to perform a vertical play inspection and should be removed to inspect. Be sure to use the correct puller to break the taper when removing the joint and do not tear the grease boot.

Once out of the car, the ball joint nut is installed onto the stud and a dial or beam type torque wrench is used to measure the amount of force required to rotate the ball within the socket. Rotate the stud slowly, about one turn every 2-4 seconds, and note the torque reading after every fifth turn.

If the turning torque is found to be excessive, the ball joint is too tight and should be replaced. Conversely, if the torque reading is too low, the joint is excessively worn and should be replaced. Refer to the torque specifications in the appropriate Repair Manual.
The spindle or axle hub assembly provides the connection between the wheels and the suspension system. The steering system is attached to the spindle assembly through a steering arm, either integral or bolted to the spindle.

Inspecting the spindle assembly primarily involves a close check of all the components attached to it. When inspecting the spindle and related hardware pay particular attention to the following:

• Wheel bearing looseness and operation (rough, noisy, etc.)
  Damage to the ball joint and tie rod mounting points (particularly taper seats)
• Brake drag and caliper mounting
• Any signs of major impact damage

Major physical damage is typically the only reason for spindle replacement. This type of damage is not always visible and will likely require an inspection of wheel alignment geometry to identify.

Wheel bearing clearance is checked using a dial indicator. Acceptable clearances for most late model vehicles range from .002” to .004”. (Refer to the Repair Manual for exact specifications.)