

# TRADE OF HEAVY VEHICLE MECHANIC

## PHASE 2

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### Module 8

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### Steering and Suspension Systems

### UNIT: 3

## Suspension Systems

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# 1.0 Learning Outcome

**By the end of this unit each apprentice will be able to:**

- Locate and identify the principle components of various suspension systems
- Explain the construction and operation of major suspension components
- Differentiate between constant and variable rate suspension springs
- Diagnose common suspension problems
- Describe safe practices for working on various suspension systems
- Perform simple checks, adjustments and repairs to various suspension systems

## 1.1 Key Learning Points

- Pascal's, Boyle's, Charles' and the Combined Gas Laws revised
- Hydraulic and pneumatic calculations using Pascal's, Boyle's, Charles' and the Combined Gas Laws to solve simple suspension system problems relating to pressure, force and area
- Spring terminology defined: vibration, amplitude, period, frequency, resonance, shock absorption and spring rate
- Calculations to determine the rate of a suspension spring given a load and a deflection
- Suspension kinematics defined: three spatial axes, moments and equilibrium
- Lateral acceleration defined
- The rationale for a suspension system
- Statutory requirements for commercial vehicle suspension systems
- Types of suspension system (simple sketches required): nonindependent, semi-independent, independent, hydraulic, rubber, gas, manual and self-levelling
- The construction and operation of the following suspension system components (simple sketches required): wish bones, control arms, bushings, ball joints, dampers (lever, telescopic and MacPherson types) and bump stops

- Procedures and techniques for checking, removing, installing and adjusting/servicing the following suspension system components: wish bones, control arms, bushings, ball joints, springs, dampers (telescopic and MacPherson types) and bump stops spring: (simple sketches required) leaf, torsion bar, coil and rubber
- Advantages of variable rate springs over constant rate springs
- Procedures and techniques for checking, removing, installing and adjusting/servicing the following types of suspension spring: leaf, torsion bar, coil and rubber
- Safety precautions for working with heavy/sprung/pressurised suspension components
- The construction and operation of a pneumatically controlled air suspension (PCAS) system (simple sketches required): air compressor, governor valve, unloader valve, safety valve, single check valve, pressure regulating valves, system protection valves (single and multi-circuit), air reservoirs, drain valves, air filter, raise/ lower valve, levelling valves (chassis and cab), isolating valve, air springs (rolling lobe diaphragm and involute bellows), bump stops and pressure indicators (stop light switches, visual and audible warning devices)
- The procedures for checking and adjusting vehicle ride height on a PCAS system
- The hazards associated with working with compressed air
- Lubrication requirements for running gear components
- Safe methods of raising, supporting and lowering a vehicle
- Procedures and techniques for recovering vehicles (lifting and towing)
- Protocols for marine transport and rough weather operation
- Proper use and care of test equipment
- Communications with instructor/classmates during the execution of tasks
- Criteria for conducting a proper road test

## 2.0 Health and Safety

If the proper safety procedures are not adhered when working on **Suspensions and Dampers** this could lead to serious injury / health problems to personnel.

Instruction is given in the proper safety precautions applicable to working on **Suspensions and Dampers** include the following:

- Danger of explosion of gas filled shock absorbers ( disposed off in accordance with environmental regulations)
- Body height adjustment
- Use of tapered joint breakers / coil spring
- Coil spring clamping equipment
- Body support system / method during suspension system removal
- Danger of serious auto–accidents if all steering and suspension bolts are not torqued to original manufacture’s recommendations
- Use of Personal Protective Equipment (PPE)

Refer to motor risk assessments, Environmental policy, and Material Safety Data Sheets (MSDS).

## 3.0 Purpose of Suspension

### 3.1 Principles of Suspension

The suspension system isolates the body from road shocks and vibrations which would otherwise be transferred to the passengers and load.

It also must keep the tyres in contact with the road. When a tyre hits an obstruction, there is a reaction force. The size of this reaction force depends on the unsprung mass at each wheel assembly



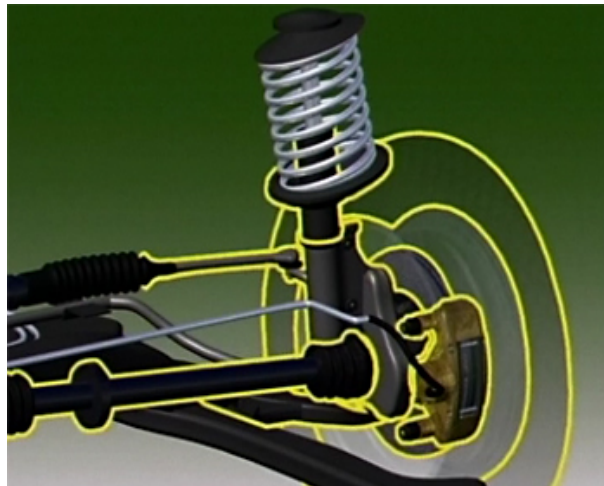
The sprung mass is that part of the vehicle supported by the springs - such as the body, the frame, the engine, and associated parts.

Unsprung mass includes the components that follow the road contours, such as wheels, tyres, brake assemblies, and any part of the steering and suspension not supported by the springs. Vehicle ride and handling can be improved by keeping unsprung mass as low as possible. When large and heavy wheel assemblies encounter a bump or pothole, they experience a larger reaction force, sometimes large enough to make the tyre lose contact with the road surface.

Wheel and brake units that are small, and light, follow road contours without a large effect on the rest of the vehicle. At the same time, a suspension system must be strong enough to withstand loads imposed by vehicle mass during cornering, accelerating, braking, and uneven road surfaces.

### 3.2 Unsprung Weight

Most of a vehicle's weight is supported by its suspension system. It suspends the body and associated parts so that they are insulated from road shocks and vibrations that would otherwise be transmitted to the passengers and the vehicle itself.



However, other parts of a vehicle are not supported by the suspension system, such as the wheels, tyres, brakes and steering and suspension parts not supported by springs. These parts are all called unsprung weight. Generally, unsprung weight should be kept as low as possible.

### 3.3 Wheel Unit Location

When a vehicle is in motion, several forces operate to displace the wheel units - driving thrust, braking torque, and cornering force. These forces must be transferred to the frame of the vehicle, but while they act, the wheel units must stay aligned with each other, and with the frame.



They must be located longitudinally, and laterally, while still having the freedom to move vertically, to allow for suspension travel.

### 3.4 Suspension Force

Leaf springs absorb applied force by flattening out under load. Coil springs absorb force of impact by twisting. Torsion bars twist around their centre.



### 3.5 Dampening

Different materials have different levels of elasticity. Up to a certain point, they can be deformed and released, and they will try to return to their original condition.

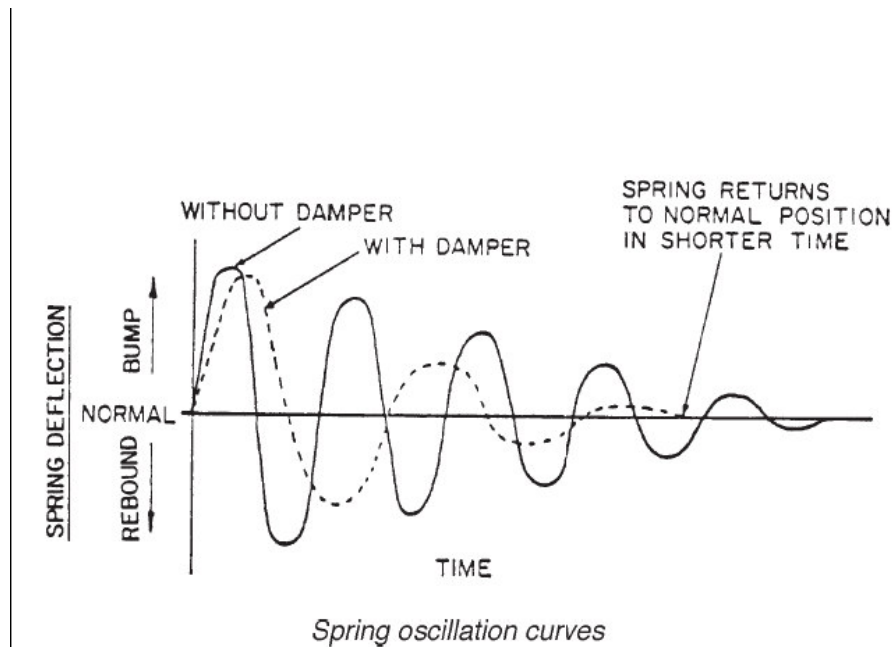
Beyond that point they stay deformed. With some materials, if it returns to its original state too quickly, it can produce a bouncing effect called an oscillation.



Preventing or reducing this oscillation is called dampening. It can occur in many different ways. The dampening material absorbs the energy from the oscillation. In vehicle suspension, a shock absorber reduces oscillation in the spring.



### 3.6 Damper Action - Diagram



#### The Damper

When the wheel strikes a bump, energy is given to the spring, which is deflected. When the bump is passed, rebound or release of the stored energy will take place, and will carry the spring past the normal position to set up an oscillating motion. This action is similar to the movement of a pendulum. A freely suspended pendulum will oscillate for a considerable time after being struck. In order to give a comfortable ride, some device must be fitted to absorb the energy stored in the spring and so reduce the number of oscillations occurring between the initial bump and the return of the spring to the rest position. This is the duty performed by the damper (often misleadingly called shock absorber).



## 4.0 Types of Suspension Systems

### 4.1 Suspension Systems

The purpose of the complete suspension system is to isolate the vehicle body from road shocks and vibrations which would otherwise be transferred to the passengers and load. It must also keep the tyres in contact with the road, regardless of road surface. A basic suspension system consists of springs, axles, shock absorbers, arms, rods, and ball joints.

The spring is the flexible component of the suspension. Basic types are leaf springs, coil springs, and torsion bars. Modern passenger vehicles usually use light coil springs. Light commercial vehicles have heavier springs than passenger vehicles, and can have coil springs at the front and leaf springs at the rear. Heavy commercial vehicles usually use leaf springs, or air suspension.



Solid, or beam, axles connect the wheels on each side of the vehicle. This means the movement of a wheel on one side of the vehicle is transferred to the wheel on the other side. With independent suspension, the wheels can move independently of each other, which reduce body movement. This prevents the other wheel being affected by movement of the wheel on the opposite side, and this reduces body movement.

When a wheel strikes a bump, there is a reaction force, and energy is transferred to the spring which makes it oscillate. Oscillations left uncontrolled can cause loss of traction between the wheel and the road surface.

Shock absorbers dampen spring oscillations by forcing oil through small holes. The oil heats up, as it absorbs the energy of the motion. This heat is then transferred through the body of the shock absorber to the air. When a vehicle hits an obstruction, the size of the reaction force depends on how much unsprung mass is at each wheel assembly.

Sprung mass refers to those parts of the vehicle supported on the springs. This includes the body, the frame, the engine, and associated parts. Unsprung mass includes the wheels, tyres, brake assemblies, and suspension parts not supported by the springs.

Vehicle ride and handling is improved by keeping unsprung mass as low as possible. Wheel and brake units that are small and light follow the road contours without a large effect on the rest of the vehicle.

## 4.2 Coil Springs

Coil springs are used on the front suspension of most modern light vehicles, and in many cases, they have replaced leaf springs in the rear suspension. A coil spring is made from a single length of special wire, which is heated and wound on a former, to produce the required shape. The load-carrying ability of the spring depends on the diameter of the wire, the overall diameter of the spring, its shape, and the spacing of the coils.

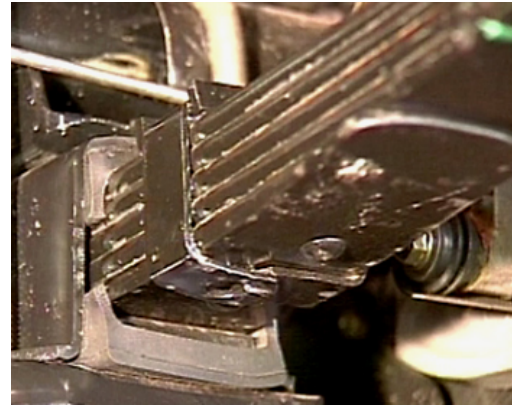


And this also decides which vehicle it is suitable for. A light commercial vehicle has springs that are robust and fairly stiff. On a small passenger car, they are lighter, and more flexible. The coils may be evenly spaced, or of uniform pitch, or unevenly spaced. The wire can be the same thickness throughout, or it may taper towards the end of the spring.

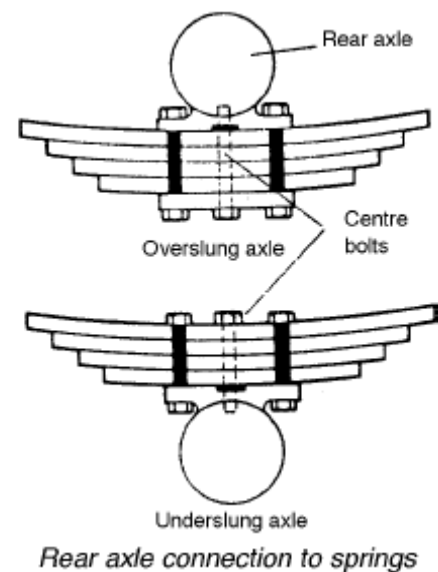
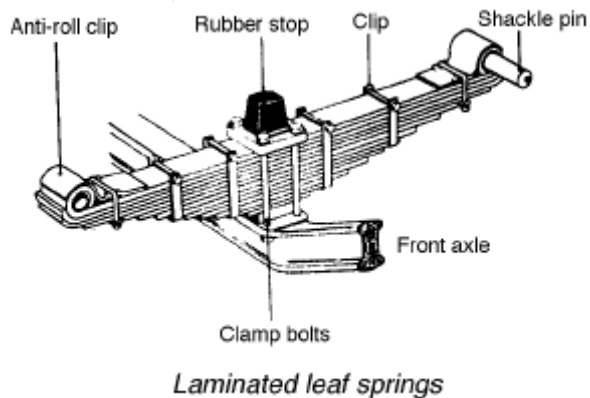
## 4.3 Leaf Springs

### Suspension system

The suspension system separates the axles from the vehicle chassis, so that any road irregularities are not transmitted directly to the driver and the load on the vehicle. This not only allows a more comfortable 'ride', and protection of the load from possible damage, but it also helps to prevent distortion and damage to the chassis frame.



On most heavy vehicles, suspension is by means of laminated leaf springs, but on some special applications rubber or air may be used as the suspension medium. Passenger vehicles often use some form of air suspension to give extra passenger comfort, but this is offset by an increase in cost.

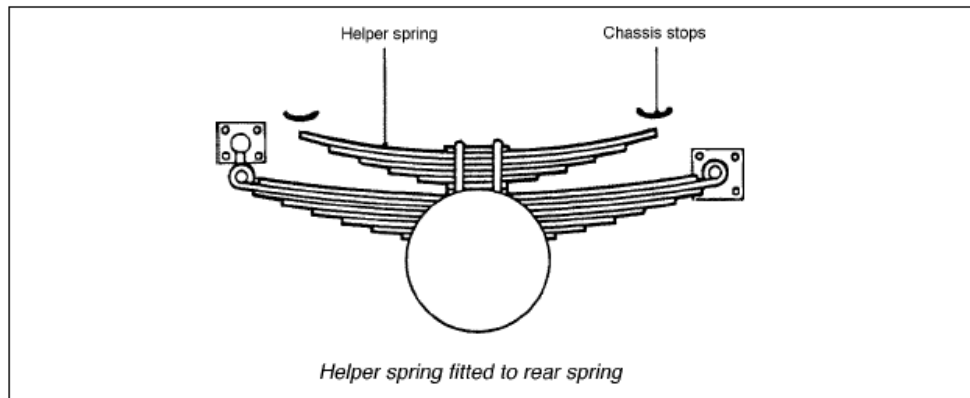


### 4.4 Helper spring

An ideal suspension system would not affect the 'ride' of a vehicle irrespective of whether it is fully laden or unladen. Unfortunately, because of the heavy loads carried by most heavy vehicles, an ideal suspension system is impossible. Large stiff springs are required to support the load and this gives a very harsh 'ride' when the vehicle is unladen. Conversely if the spring were too soft it would deflect too much or break when carrying a full load. The spring 'rate' is the amount of deflection of the spring for a given load.

If the spring could have a variable rate it would be possible to stiffen the spring when more load was added and still give an acceptable ride when unladen.

On vehicles fitted with laminated leaf springs, this stiffening effect is achieved by fitting a helper spring above the main spring. When lightly loaded the main spring carries the weight but as the load is increased the helper spring contacts spring seats on the chassis and the suspension is stiffened as both the helper and main springs now support the load.

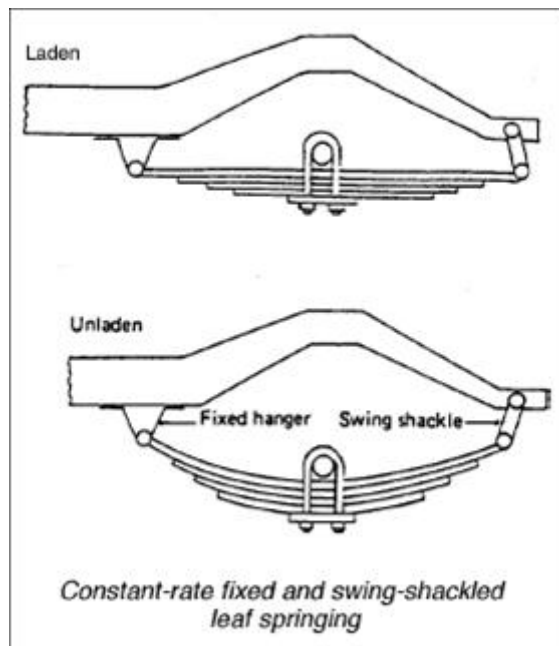


#### 4.5. Constant-rate and progressive-rate semi-elliptic springing

There are two basic methods of mounting a semi-elliptic spring to the chassis, as follows:

##### Constant-rate swing springs:

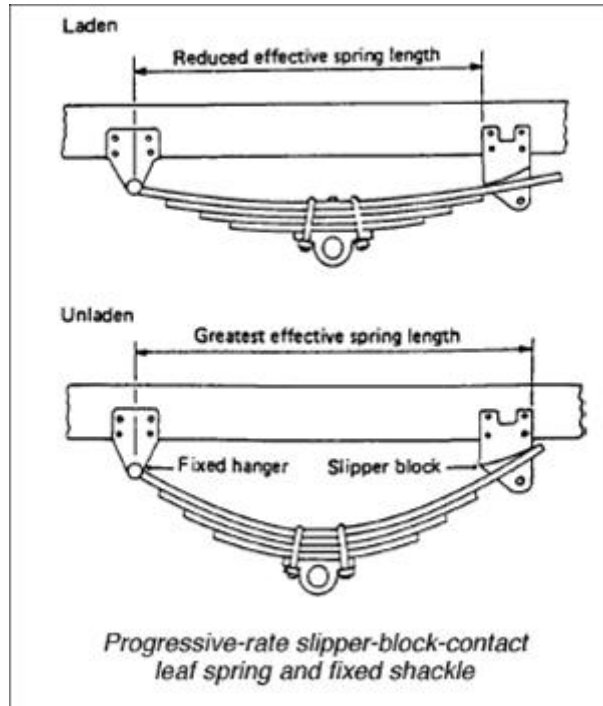
With this method, the forward end of the spring is directly pinned to the front spring-hanger and the rear end to a swing shackle. When the spring is deflected between the unloaded and the loaded position, the spring camber will be reduced and the spring length will increase. To allow this to take place, the swing shackle will pivot about the upper fixed shackle-pin. The driving thrust can then be transmitted through the forward half of the spring directly to the fixed spring-hanger.



There will be very little change in the spring stiffness as the spring straightens out, hence this is known as a constant-rate suspension spring.

**Progressive-rate slipper spring:**

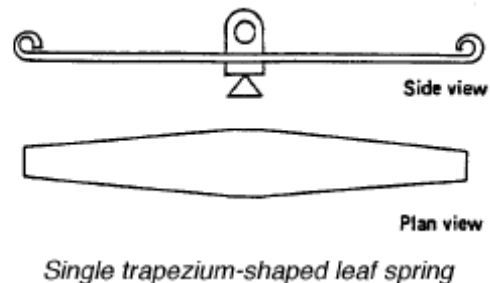
With this method of supporting the spring ends, the forward end is attached directly to the spring-hanger as before, but the rear end has no eye but just rests on a curved slipper block or pad. Initially, when the spring is unloaded, the contact point will be on the outside position of the slipper face, but the straightening of the spring as the load is increased will roll the mainleaf end around the slipper profile from the outer to the inner position. This effectively shortens the spring length. This is



equivalent to stiffening the spring, or increasing the spring rate, which will therefore offer a progressively increased resistance to the vehicle payload.

## 4.6 Single trapezium-shaped leaf spring

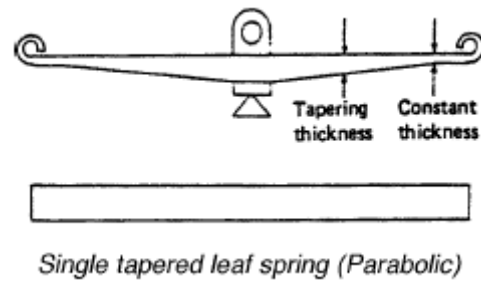
Another approach to maintaining an approximately constant stress distribution along the spring span is to have a single spring blade of uniform thickness but increasing in width from its ends towards the mid span. A plan view shows a trapezium shape.



The increase in cross-sectional area towards the middle of the spring blade counteracts the increase in bending moment created by the body weight, so that the spring remains uniformly stressed along its length.

## 4.7 Single tapered leaf spring

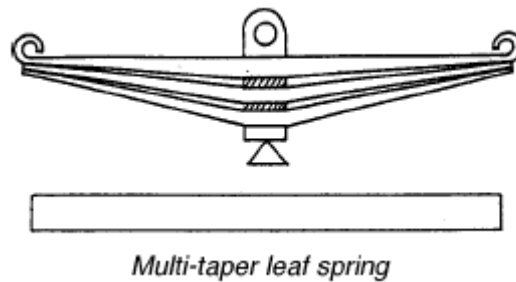
A more popular approach using a single leaf spring is to have the blade of constant width but to taper its thickness from a maximum in the mid-span position to a minimum at its ends as shown. With this shape, the increased bending moment from the spring ends of the axle centre will be resisted by the proportionally enlarged cross-sectional area of the blade.



The taper leaf seems to be preferred to the trapezium shape as it is more compact and easier to clamp on to the axle-beam.

## 4.8 Multi-taper-leaf springs

For heavy-duty large tractors or trucks, two or three taper-leaf springs may be used together. Liners may be used between the pressure points at the mid spring seat position, so that the springs do not touch at any point between the middle seat section and the load bearing end points.



### Advantages of taper-leaf over multi-leaf springs:

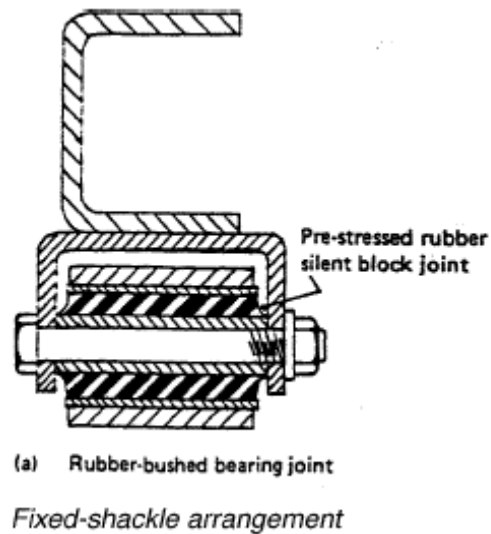
The advantages of taper-leaf over multi-leaf springs are as follows:

- (a) The variable-cross-section single-leaf spring is only about half the weight of a multi-leaf spring used for the same payload.
- (b) There is no interleaf friction with the single taper blade. Where the taper-leaf application has more than one leaf, inter-leaf friction is reduced because fewer leaves are required and because these leaves bear upon each other only at the ends. This provides a more sensitive springing for light road shocks and so gives a better ride.
- (c) The taper-leaf spring stresses are more uniform and lower overall than with the multi-leaf design. Taper-leaf spring life is therefore longer.
- (d) With the single-taper-leaf spring, there is no inter-leaf collection of moisture and trapped dirt which would promote fretting corrosion and fatigue failure.



## 4.9 Leaf-spring shackle arrangements

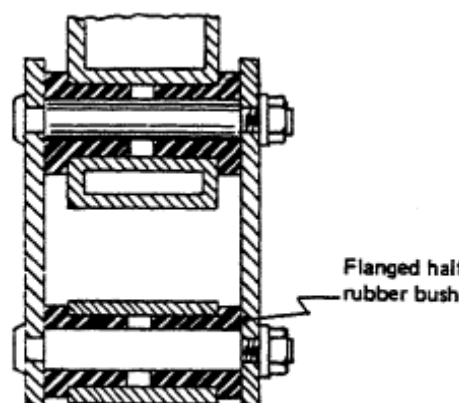
To obtain an efficient suspension, the vehicle weight must be transmitted to the leaf spring by means of a fixed spring-mount or hanger at the front end of the spring and usually a swinging shackle at the rear end. The spring is attached or hinged at each end by shackle-pins passing through the spring eye and the mounting or shackle-plate. These pins provide a joint which can rotate or pivot in rubber or metal bushes but at the same time be firmly held together. This reduces wear and noise and does not alter the suspension and steering geometry as the spring deflects and the various forces act on the system.



Rubber bushes are generally used for cars and vans, but metal phosphor-bronze bushes are provided on heavy-duty commercial vehicles. There are two types of rubber bushing commonly used:

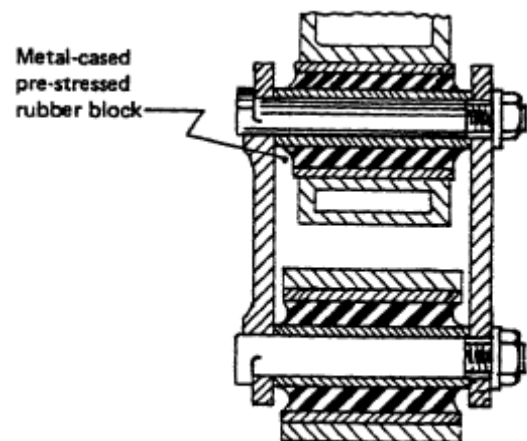
- (i) flanged rubber half-bushes and (ii) silent block bushes.

### Flanged Rubber half-bushes



(a) Plain rubber-bushed bearing joint

### Silent block rubber bushes



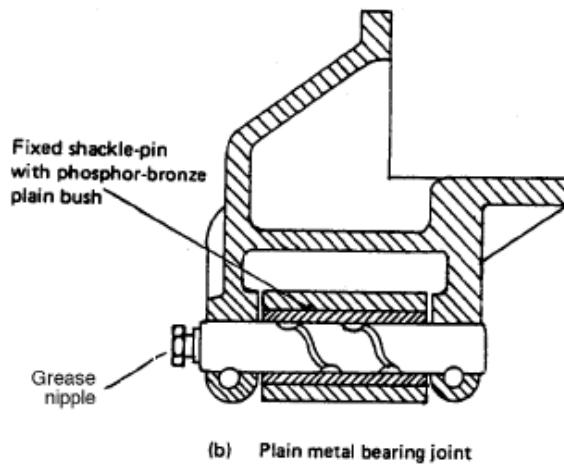
(b) Silent rubber bearing joint

### Swinging-shackle arrangements with rubber bushes

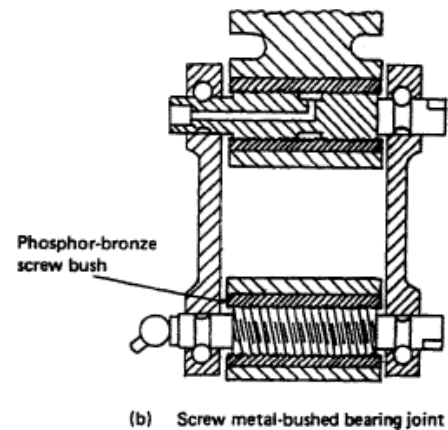
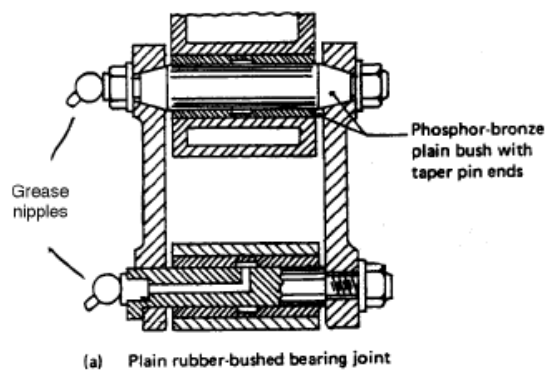


## 4.10 Metal bushes

For heavy-duty applications, metal bushes are used. These can either be plain or screw profiled, and both types are a force fit in the spring eye or spring mounting hanger. Rubbing between the shackle-pin and the metal bush must be minimised, so they are always lubricated by holes drilled axially along the shackle pin. A radial intersecting hole in the middle of the pin permits the passage of grease between the pin and the bush. Plain bushes are usually helically internally grooved so that the grease will spread more evenly over the bush bearing surface. With the screw-type pin-and-bush joint there will be both rotary and axial movement when the spring is deflected, so the grease should readily spread over the bearing-surface pair.



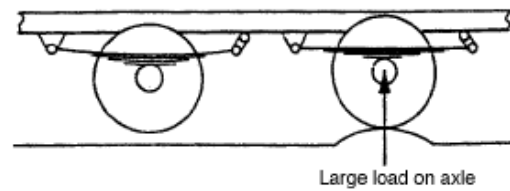
*Fixed-shackle arrangement*



**Swinging-shackle arrangements with rubber bushes**

## 4.11 Suspension systems for tandem rear axles

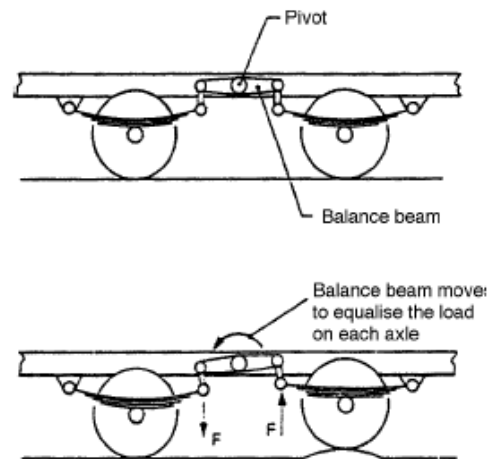
On heavier goods vehicles, which use two axles at the rear because of the weight regulations, the axles must be mounted as close together as possible in order to eliminate tyre scrub when cornering. The wheels must try to follow a common turning point, but this is impossible when two axles are used. Apart from this, both axles must be interconnected to eliminate overloading of one axle when this goes over a 'bump'.



*Suspension system which does not distribute the load*

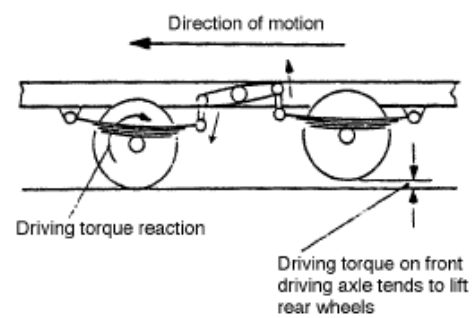
Various forms of interconnecting linkage are used and some are more effective than others in equalising the loading under all conditions.

The simplest form of interconnection in a double drive layout is a simple balance beam (walking beam) which connects the rear swinging shackle of the forward spring to a swinging shackle on the front of the rear spring. When the front axle negotiates a bump the balance beam pivots at the centre and allows load equalisation on each axle to the limit of travel of the beam.



*Balance beam move to equalise the load on each axle*

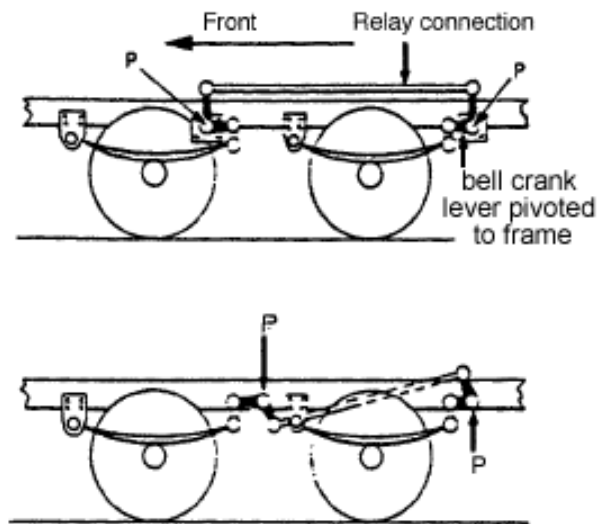
When accelerating, as mentioned previously, the spring is subjected to twisting. In this particular layout, under these conditions, the forward spring will tend to move down at the rear and the rear spring will tend to move up at the front owing to the torque reaction. Both of these reactions will tend, through the balance beam, to have some load transference under these accelerating conditions to the front of the two axles. This means that the forward axle is temporarily subjected to more load than the rear axle which could lead to possible wheel spin on the rear axle wheels under this condition. When braking, the torque reaction acts in the opposite way with similar effects. This type of suspension is referred to as a reactive suspension.



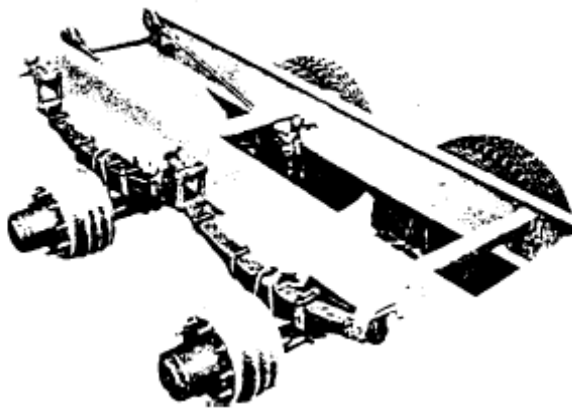
*Reactive rear suspension*

## 4.12 Non-reactive suspension

**Figure 1** a shows a typical non-reactive suspension system. When the forward axle moves over a bump, the linkages equalize the loading with the rear axle. When accelerating, the torque reaction in the forward spring tends to move the linkages as shown. At the same time the torque reaction in the rear spring moves to oppose the movement by the forward spring, therefore any transfer

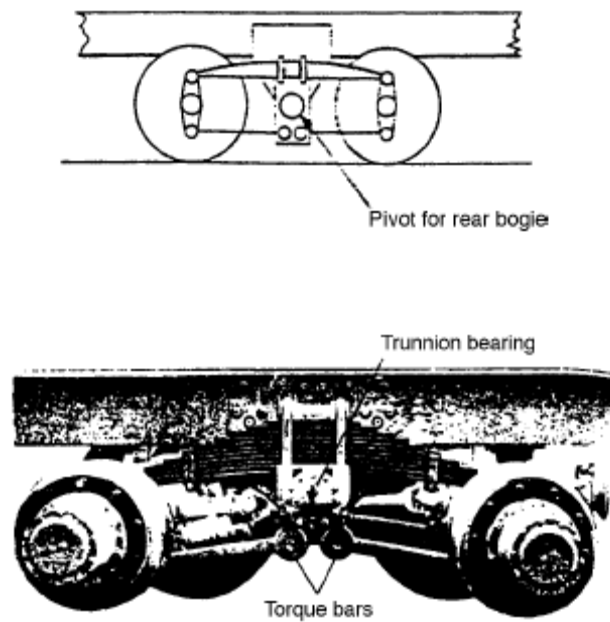


of load under this condition is balanced against each axle and no movement takes place. Even if one axle were negotiating a bump at the same time the axle loading would be balanced out. Torque reaction due to braking is balanced out in the opposite direction to driving torque reaction under all conditions.



**Figure 1 – Non-reactive rear suspension**

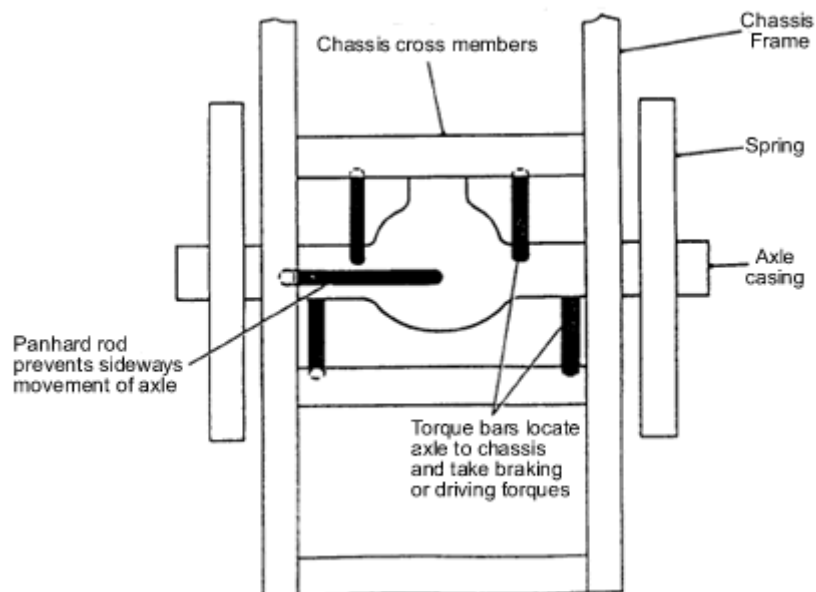
When a degree of movement between the axles in a tandem bogie layout is desirable—vehicles used on site work or vehicles which spend more of their driving time in off-road situations—a further type of suspension layout can be used. This can be either a single spring or a twin spring layout with the springs mounted on trunnion bearings (Figure 2).



**Figure 2 – Non-reactive suspension**

When using this layout, the springs can be laminated leaf, taper leaf or single leaf with slipper-type mountings at both ends of the springs. This means that the driving thrust, driving and braking torque reactions cannot be taken by the springs. Both axles are then held by torque bars and Panhard rods which locate the axle to the chassis frame and take all other torques usually taken by the springs. This layout also means that the springs can be designed for suspension only and allows a greater difference in levels between the two axles. Both systems are of course non-reactive layouts.

### Axle Location



### 4.13 Torsion Bars

A torsion bar is a long, alloy-steel bar, fixed rigidly to the chassis or sub-frame, at one end, and to the suspension control arm at the other. The bar is fitted to the control arm in the unloaded condition, and as the control arm is raised, the bar twists around its centre, which places it under a torsional load.



When the vehicle is placed on the road, with the control arm connected to the suspension assembly, the bar supports the vehicle load, and twists around its centre, to provide the springing action. Spring rate depends on the length of the bar, and its diameter. The shorter and thicker the bar, the stiffer its spring rate.

Torsion bars can be used across the chassis frame on the same principle, in a trailing arm suspension, or as part of the connecting link between 2 axle assemblies, on a semi-rigid axle beam. After a lot of use, a torsion bar can sag. On many vehicles, it can be adjusted to allow for this. It is used in light vehicles as a stabilizer, or anti-roll bar, connected between each side of the suspension on the front, and sometimes the rear.

When the vehicle is turning, centrifugal force acts on the body, and tends to make it lean outwards. The anti-roll bar, or stabilizer, tries to use its connections to each side of the suspension, to resist this roll tendency.

## 4.14 Rubber Springs



Rubber is used in most suspension systems as bump and rebound stops. If the suspension reaches its limit of travel, these stops prevent direct metal-to-metal contact, which reduces jarring of the body of the vehicle. The stops can also be shaped to provide an auxiliary springing function, increasing their resistance progressively with suspension contact.

## 5.0 Types of Axles

### 5.1 Solid Axle

The solid or beam axle provides a simple means of locating and mounting the hub and wheel units. Together with leaf springs, it forms an effective, non-independent suspension system. Similarly, with coil springs.



It is still used in the rear suspension of many front-engine, rear-wheel-drive cars, and light commercial vehicles, and as the front suspension on many heavy commercial vehicles.

On rear-wheel-drive vehicles, with leaf springs, the axle housing is held in place by the springs, and no other form of location is needed.

The drive is transmitted through the final drive unit and axles to the wheels, and therefore the axle is referred to as a live axle.

When a vehicle accelerates from rest, the resistance of its mass causes a torque reaction, producing a tendency for the axle housing to rotate in the direction that is opposite to wheel rotation.

A similar effect occurs during braking, but with the twisting effect in the direction of wheel rotation.

In both cases, this tendency can cause leaf spring wind-up, and the twisting action can interfere with suspension motion.

## 5.2 Dead Axle



On front-wheel-drive vehicles, a simple **beam axle** can be used on the rear, with coil spring suspension and control arms for location. This is called a dead axle, since it only supports the vehicle and doesn't transmit any drive. It is also non-independent, as deflection of a wheel on one side of the vehicle will be transferred to the other wheel.



### 5.3 Independent Suspension

One of the main benefits claimed for independent suspension is that unsprung mass can be kept low. Also, if a wheel on one side hits a road irregularity, it won't upset the wheel on the other side on the same axle. And it allows wheel camber to be adjusted individually, when provided for by the manufacturer. One of the simplest and most common, independent suspension systems are the **McPherson strut type**. It can be used on the front and rear of the vehicle.



It consists of a spring and shock absorber unit called a strut. The lower end of the strut is located by a ball joint, fitted to the end of the suspension control arm. Its upper end is located in a moulded rubber mounting. If the unit is on the front, the upper mounting includes a bearing to allow the complete strut to rotate with the steering.

A tension rod, or stay bar, extends from the body sub-frame, to the outer end of the control arm. This maintains the location of the control arm during braking, and accelerating. In this front-wheel-drive suspension, the control arm is a wishbone shape with 2 widely-spaced mounting points. This prevents backward and forward movement, so a tension rod is not needed. Wishbones can also be used in a parallel link system. They can be used in pairs with the coil spring between the lower wishbone, and the suspension cross-member. Alternatively, the upper link may be a wishbone, with the coil spring mounted above, combined with a single-pivot lower link, located by a tension rod. On some vehicles, a torsion bar provides the springing medium. The torsion bar is attached at the inner fulcrum point of the wishbone, or control arm. As the suspension is deflected, it twists around its centre.

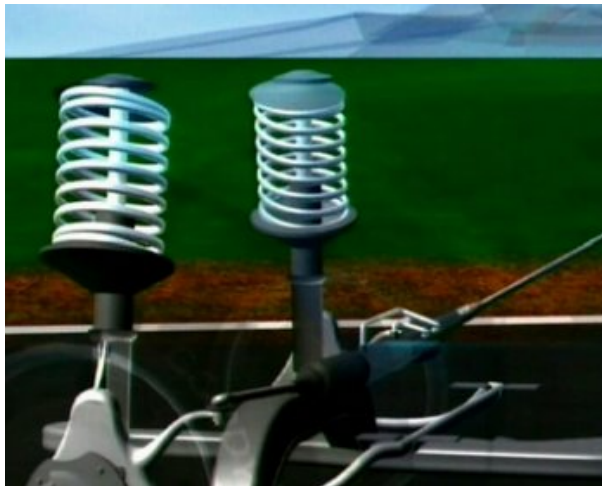
It can be fitted to the upper, or the lower link, depending on the type of vehicle. The upper link is shorter than the lower one – irrespective of the springing method used. When the suspension is deflected, the unequal lengths allow the track of the vehicle to be maintained near constant, but with some changes to camber angle.

Generally, when the car leans during cornering, the inner wheel leans outwards at the top, and the outer wheel leans inwards. This helps to maintain maximum tyre contact with the road surface.

## 5.4 Rear Independent Suspension

The kind of independent suspension used on the rear of a vehicle depends in part on whether it is front-wheel-drive, or rear-wheel-drive.

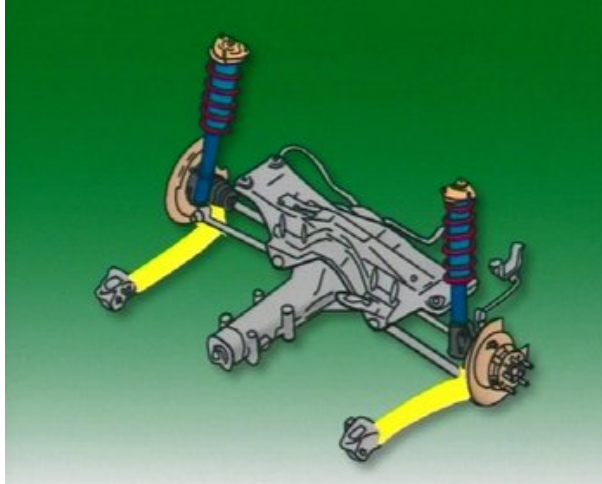
If it is front-wheel-drive, it may use a McPherson strut system at the rear, similar to the front suspension system. There is normally no steering on the rear wheels, so there is no need for the bearing in the upper mounting.



On rear-wheel-drive vehicles, the suspension arrangement has to allow for the external drive shafts to transfer the drive to the wheels.

## 5.5 Rear Wheel Drive Independent Suspension

On rear-wheel-drive vehicles with independent suspension, the final drive unit is fixed to the vehicle frame. Drive is transmitted to each wheel by external drive shafts. Suspension is normally by coil springs, and each wheel unit is located by a combination of lateral, and longitudinal control arms, or by semi-trailing arms to the frame.



Front suspension systems are normally independent, but in addition to their suspension function, they have to allow for swivelling of the front wheels during steering. This is catered for by ball joints, or bearings, that also allow for suspension movement. The ball joints locate the wheel assemblies on lateral wishbones, or control arms.

## 6.0 Shock Absorbers and Mounting Bushings

### 6.1 Hydraulic Shock Absorbers

The most widely-used hydraulic shock absorber is the direct-acting telescopic type. It can be fitted as a self-contained unit, or combined with a suspension strut. The strut type uses the same principle of operation but it is considerably larger. The hydraulic shock absorber provides its dampening action by transferring oil, under pressure, through valves which restrict the oil flow.



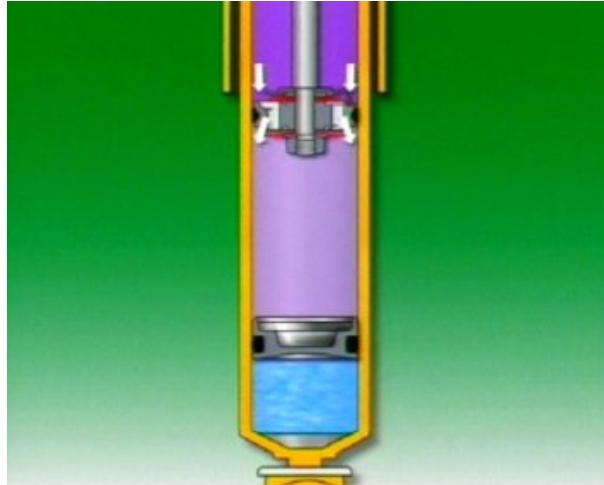
The twin-tube type is the most common. The outer tube is normally attached to the suspension member at its base, and the inner tube provides a working cylinder for a piston which is attached to a piston rod. The piston rod is connected to the frame at its outer end, and a bearing at the top of the outer tube keeps the rod in alignment as it moves in and out of the shock absorber, with suspension action.

A seal above the bearing prevents oil leakage, and keeps out dirt and moisture. A shroud protects the rod from damage. During bumps, or compression, the rod and its piston move into the shock absorber. In rebound, or extension, the rod and piston move out of the shock absorber.

For dampening to be effective, resistance is needed in both directions. This is provided by the oil, and by disc valves attached to the piston and the base of the inner tube. Oil fills the inner tube and surrounds its outer surface to a level which allows a free space or reservoir to exist above it, between the inner and outer tubes.

## 6.2 Gas-Pressurised Shock Absorbers

In a hydraulic shock absorber, the oil heats up as the energy of motion of the suspension is dampened. The rapid piston movement as the vehicle moves over the road causes the hydraulic fluid to aerate. This reduces the dampening effect, and the shock absorber's performance very quickly deteriorates. This condition is called shock absorber Dissolve. It can be reduced substantially by pressurizing the fluid with gas, usually nitrogen.



In this mono-tube design, fluid fills the chambers above and below the piston. As the piston moves in the cylinder, valves control the movement of oil from one chamber to the other. Pressure on the oil is provided by nitrogen gas at the base of the cylinder, acting on a free-floating separation piston which separates the gas from the oil.

On bump, the piston moves downwards, and the penetration of the piston rod displaces a quantity of oil equal to its volume. The separation piston is displaced accordingly, and gas pressure increases. On rebound, the piston and rod move upwards, and gas pressure reduces as the separation piston follows the movement. Pressure on the oil is maintained, even when the piston and rod are at the top of their stroke.

Disposal of gas pressurised shocks, like all other used units must be disposed in accordance with current law and legislation.

## 6.3 Bushings

Bushes, or bushings, act as bearings at suspension fulcrum points, to allow for movement of the component, while maintaining its alignment. They can be metallic, or made of rubber, nylon, or urethane.



## 6.4 Arms & Linkages

The major components of the suspension system must be firmly located, to withstand the forces that occur in normal operation. Control arms fasten a component like a rear axle assembly to the vehicle body, while allowing it to move as it needs to, similarly, with a steering knuckle.



The arms must be strong enough to withstand the forces due to normal operation, but light enough to minimize the vehicle's unsprung mass. The front suspension can have 1, or 2, control arms. Parallel-link front suspensions have 2 control arms.



Vehicles with strut-type front suspension have only 1 arm. It can be a wish-bone shape with 2 fulcrum mounting points, or straight with single fulcrum. The inner end of the control arm is bushed to the vehicle body, and the outer end uses a ball joint to allow changes in the steering angle for turning.

Trailing arms, or control rods, are used to position the axle longitudinally. They have flexible rubber mountings at each end where they locate on the axle housing, and on the chassis frame. They would allow the axle to move laterally if it were not restrained. Any such movement has to be controlled to keep correct alignment with the front wheels, and the vehicle frame. This suspension system uses angled, upper-control rods, to limit lateral movement of the rear axle, during cornering. They also absorb the torque reaction forces, which limit rear axle wind-up during accelerating, and braking.

A panhard rod may be used to restrict lateral movement of the rear axle during cornering. It has bushes or mountings at each end, where it locates on the axle and frame. This allows for variations in load, while maintaining correct alignment. The axle may also be located by a Watts linkage. A lever, mounted on a pivot near the centre of the axle housing, is connected by rods to the frame, on each side of the vehicle. This maintains the axle in alignment with the frame, while still allowing the suspension to move vertically.

## 7.0 Suspension System Checks

### 7.1 Checking Coil Spring

**Note:** Design a Work flow chart that describes the dismantling and reassembly procedures for major suspension system components / units (McPherson strut, coil springs, track control wishbone / arms etc) and to manufacturer recommended procedures.





## 1. Check coil spring



Remove the tire and wheel assembly to gain better working access.



Check the coils for any signs of cracks or fatigue, such as any nicks or scores on any of the coils.



Also check the insulating block between the top of the spring and the vehicle body for signs of splitting and chaffing. Any deterioration should be reported.

## 2. Check McPherson strut upper mounting point



Check the upper mounting point of the McPherson strut for tightness.



Ensure the spring insulator is in position.

*(continued over...)*

### **3. Check leaf spring (continued)**

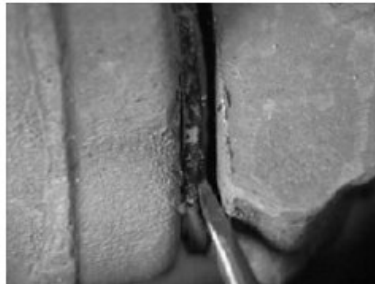


Check the condition of the bushes or mountings and spring shackles.



You can check these by putting a lever in between them and levering against the spring.

### **4. Check the suspension to body mountings**



Inspect the bushes or rubber mountings for any signs of deterioration, swelling or crushing.



Check the tightness of the bolts. Report any loose mounting bolts or retainers to your supervisor. These joints can also be a source of body noise that can be difficult to diagnose.

### **5. Check vehicle height**



Replace the wheels and lower the vehicle.



Check that the tire air pressures are correct,

### 5. Check vehicle height (continued)



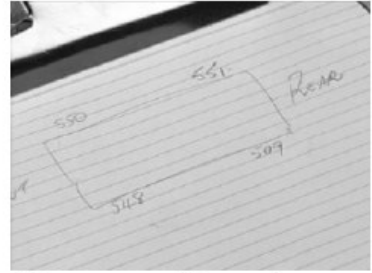
and then measure from the bottom of each wheel rim to the center of each wheel arch or opening.



Record your readings.



After you have completed measuring both sides and front to rear, compare the readings to the manufacturers specifications.



If there are any differences in height, you will need to consult the shop manual for the allowable tolerances.



Any major differences in the readings could indicate that the suspension springs are worn and have sagged. Report the findings to your supervisor.

## 8.0 NCT Requirements

Please refer to item 42 to 46 and 48 of NCT manual 2004.



An tSeirbhís Oideachais Leanúnaigh agus Scileanna  
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