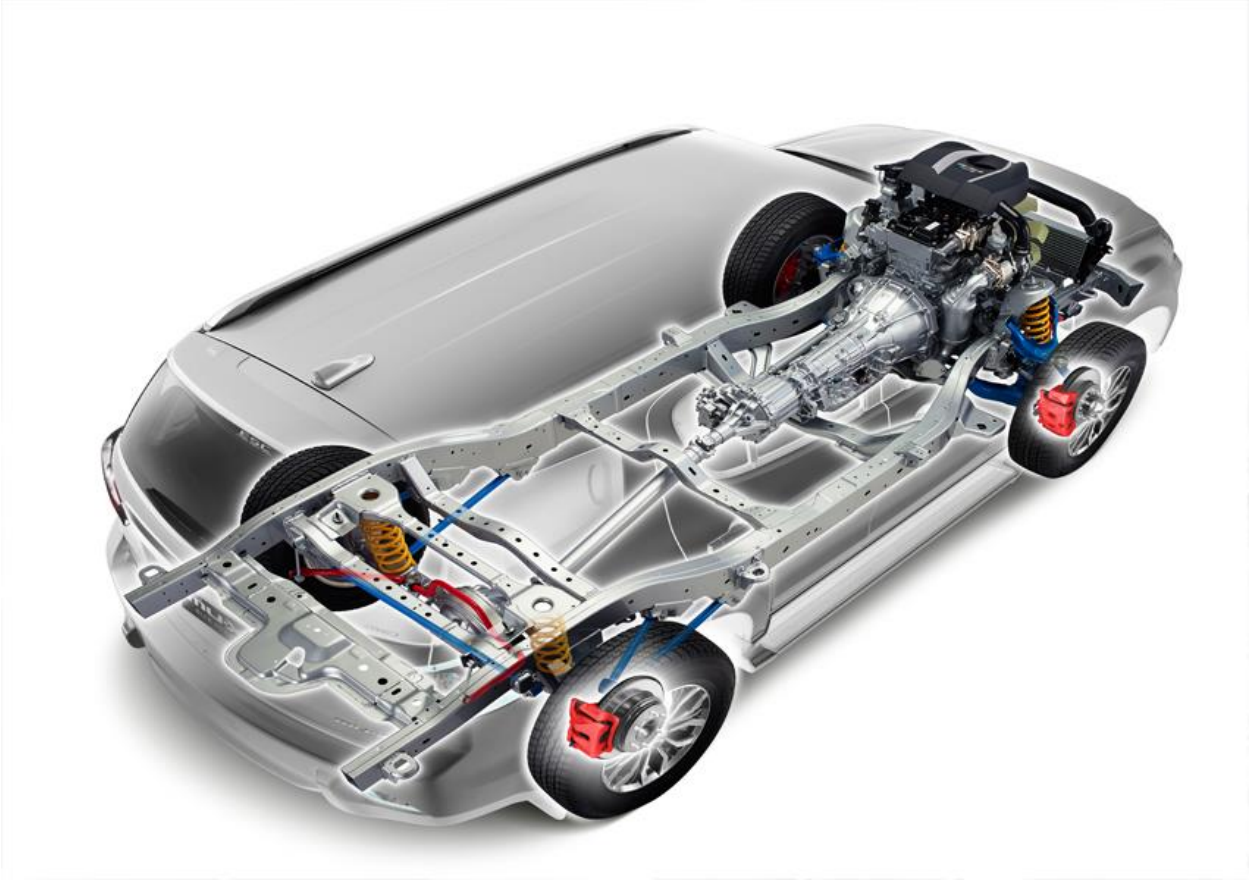
# ISUZU E-Learning System

# Module 3: Chassis



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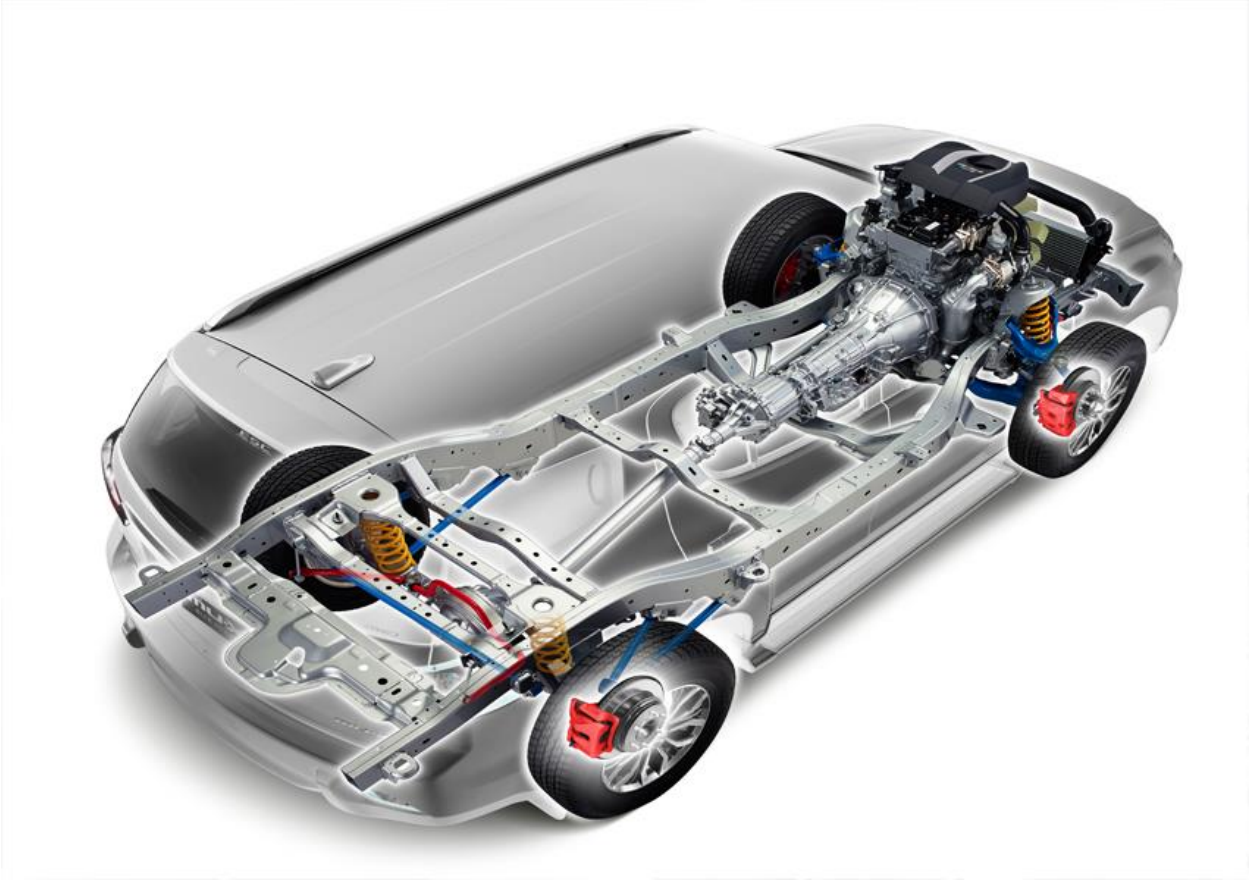
# Transmissions



# Transmission

## Introduction

An engine provides power and torque based from their respective maximum rpm. But driving conditions may vary depending on the load the vehicle carries as well as its speed and such engine speed may not be enough to provide torque and output the vehicle needs.

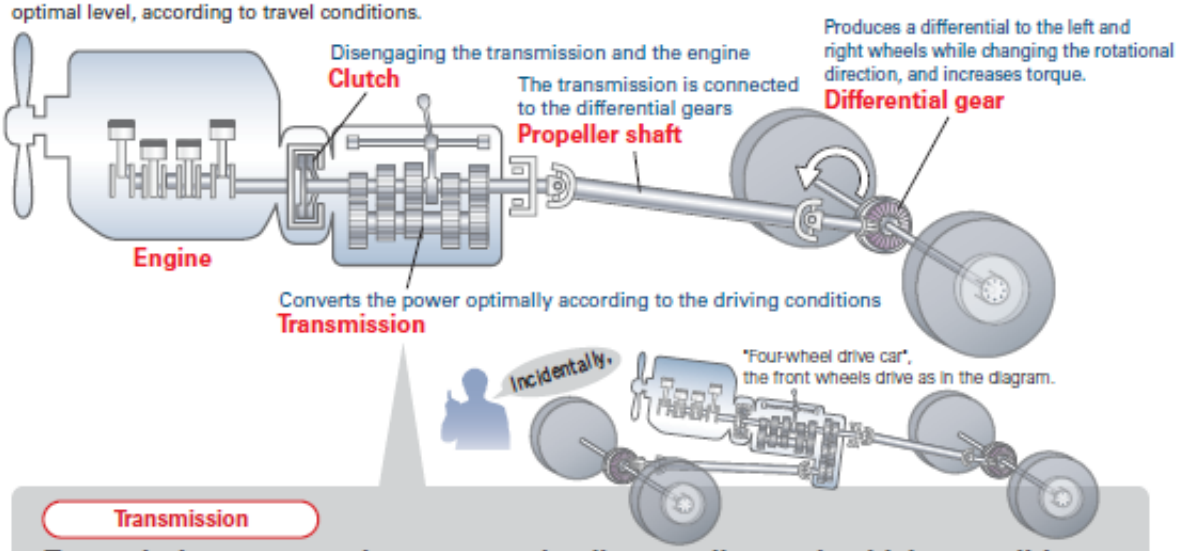
A transmission provides control of torque and output from the engine and transmit it to drive wheels, optimizing the engine's potential. It does so by:

- Converting higher engine speed to slower wheel speed to increase torque.
- Multiplying engine speed to faster wheel speed to propel the vehicle faster during highway driving.
- Reversing the direction of rotation of the propeller shaft in order to run the vehicle in reverse.

# Transmission

## Process of power transmission

Power generated by the engine is not directly transmitted to the wheels, but rather in the following order: clutch -> transmission -> propeller shaft -> differential gear. In this process, the transmission converts the engine power at the optimal level, according to travel conditions.

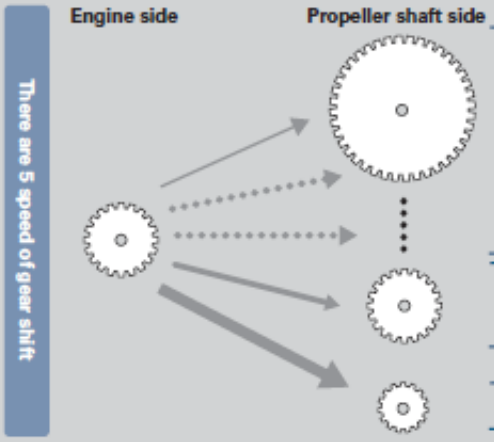



## Transmission

### Transmission converts the power optimally according to the driving conditions

The transmission has a combination of small and large gears. The gears are turned by meshing with the gears attached to the engine side, and the size of the gears can change the gear ratio between the engaging gears. By this process, the optimal driving force or engine speed can be produced to meet the driving conditions.

### If the combination of gears is changed (gear ratio change), the "torque" and "engine speed" will change.




**1-3 speed: Speed reduction gears**

When the gear by the propeller shaft side is larger than the one by the engine side, the engine speed becomes lower but the torque becomes larger. This is suitable for the types of driving which require power (rather than speed), such as starting, accelerating, and climbing a sloped road.

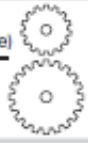
**4-speed: Top gear**

Direct coupling gear, in which the engine speed and torque are transmitted directly as they are. Compared with the reduction gear, the engine speed will increase, but the torque will be smaller.

**5-speed: Overdrive gear**

When the gear by the propeller shaft side is smaller than the engine side, and the engine speed increases more than the top gear. However, the torque becomes smaller.

$$\text{Gear ratio} = \frac{\text{Size of gear which is turning (Gear by the propeller shaft side)}}{\text{Size of the gear to turn (Gear by the engine side)}}$$

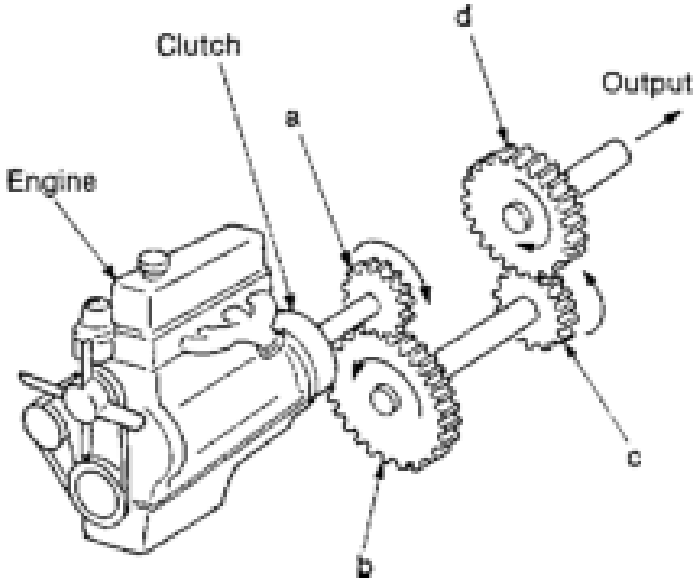


(Size of the gear that is turned is based on the size of the gear that is turning)

# Transmission

## Concept of Gear Ratio

Gear Ratio is the combination of gears with different sizes used by the transmission in order to increase either torque or speed or change the direction of rotation of the drive shaft relative to the engine crank rotational speed and direction.

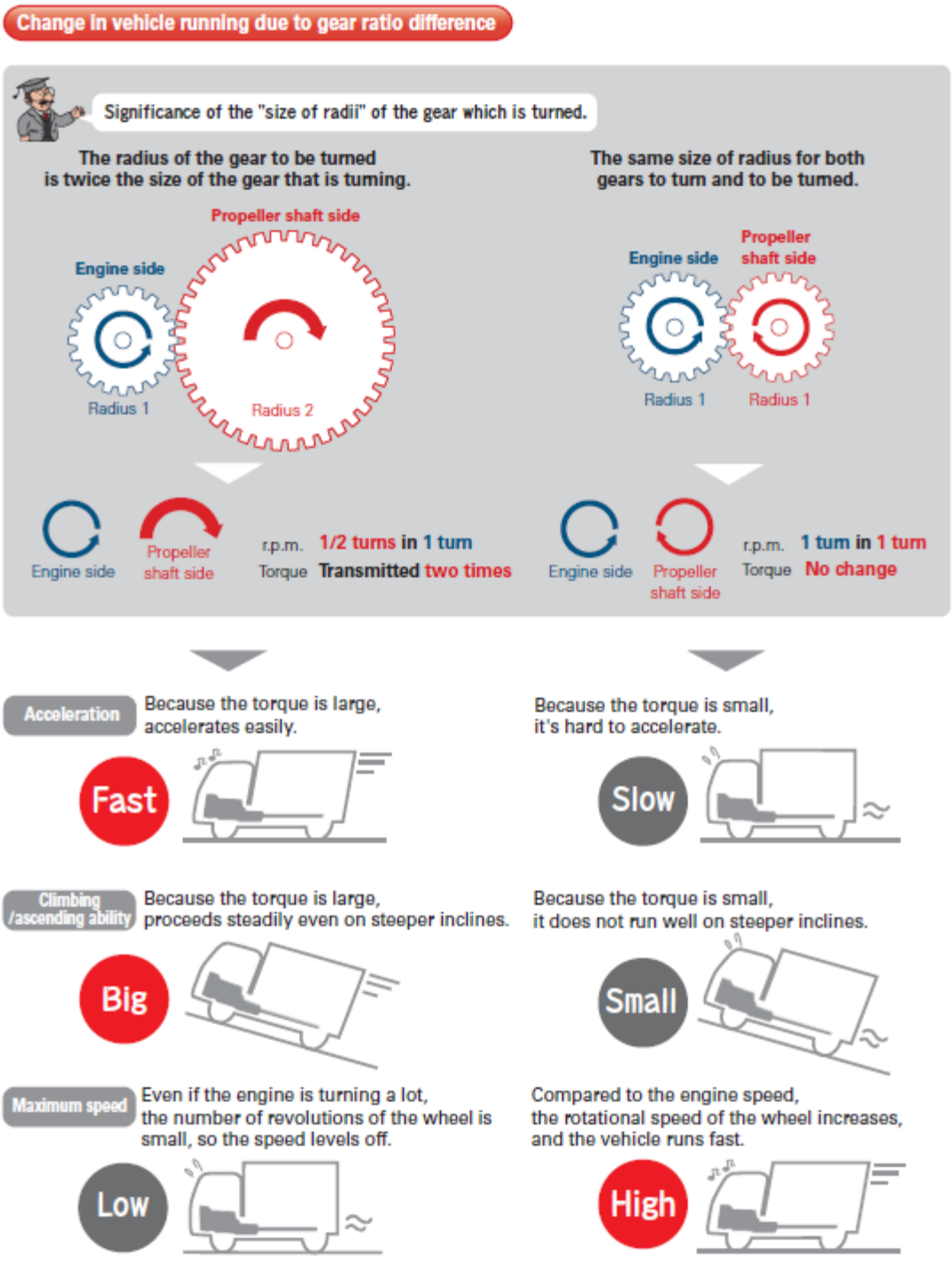



Gear ratio of a particular gear combination can be computed using the formula:

$$\text{Transmission gear ratio} = \frac{\text{Number of teeth of driven gear b}}{\text{Number of teeth of drive gear a}} \times \frac{\text{gear d}}{\text{gear c}}$$

# Transmission

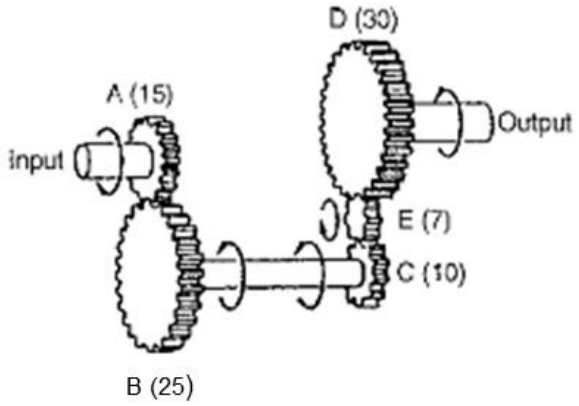
## Concept of Gear Ratio



# Transmission

## Concept of Gear Ratio

In order to reverse the direction of rotation of the driveshaft with respect to the input shaft, an Idler Gear is used.




**Combination of gear teeth (reverse)**

Computing for the gear ratio of reverse will give us:

[With idle gear]

$$\frac{\text{B teeth (25)}}{\text{A teeth (15)}} \times \frac{\text{E teeth (7)}}{\text{C teeth (10)}} \times \frac{\text{D teeth (30)}}{\text{E teeth (7)}} = 5$$

[Without idle gear]

$$\frac{\text{B teeth (25)}}{\text{A teeth (15)}} \times \frac{\text{D teeth (30)}}{\text{C teeth (10)}} = 5$$

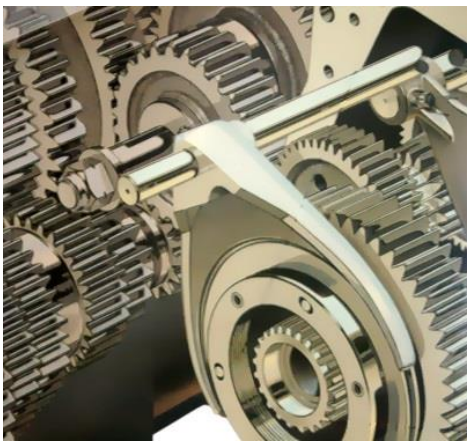
As observed, with or without idler gear, gear ratio will still be the same.

# Transmission

## Types of Manual Transmission

There are three types of manual transmissions:

*Sliding Mesh* – A transmission that has multiple gear ratios including a reverse. It uses spur gears and engagement of gears is done by matching the speeds of the gears and sliding the main gear to its respective counter gear or 'Shifting".



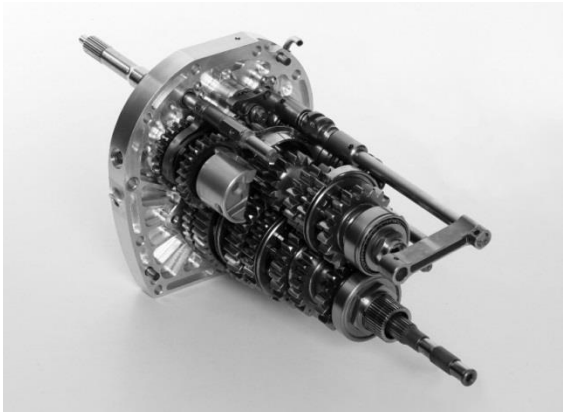
"Rev matching" or matching of gears is done in order to avoid clashing or grinding noise as well as damage to the gear train.

# Transmission

## Types of Manual Transmission

There are three types of manual transmissions:

*Constant Mesh* – A transmission that uses helical gears instead of spur gears used by the sliding mesh transmission. The gears are in constant mesh with each other and gear engagement is done by sliding the dog clutch. Mostly used in Sequential Gearboxes of motorcycles and high performance cars.



# Transmission

## Types of Manual Transmission

There are three types of manual transmissions:

*Synchro Mesh* – A type of manual transmission similar to that of a constant mesh transmission that both main and countershaft gears are constantly meshed with each other. The difference is that it uses cone shaped synchronizer rings which matches the speed of the main gear with the counter gear for smooth engagement of gears during shift.


# Transmission

## Components of Manual Transmission

*Clutch* – it is a device used to couple or uncouple the manual transmission and the engine in order to have smooth gear shifting when disengaged, provide good connection with the engine when engaged and give proper amount of slip during vehicle start to prevent jerking.

Purpose of Clutch System:

- ✓ To facilitate engine starting
- ✓ To set the vehicle in motion without juddering
- ✓ To ease gear shifting
- ✓ To reduce the impact of the rotating power on the powertrain when the vehicle is in motion

# Transmission

## Components of Manual Transmission

Classification of Clutch System.

1. **Mechanical Friction Clutch**
   - **Disc Clutch** — Driving and driven plates have disc-shaped friction surface
     - **Dry Type** — Friction heat is cooled by direct exposure to air
       - **Single Disc Type** — Has one friction plate
         - **Coil Spring**
         - **Diaphragm Spring**
       - Multiple Disc Type — Has two or more friction plates
     - Wet Type — Friction heat is Cooled by oil
   - Cone Clutch — Driving and driven plates have conical friction surfaces. Not used due to large inertia upon clutch disengagement

**Dry Type Single Disc Clutch**

**Dry Type Multiple Disc Clutch**

2. **Fluid Clutch**
   - Fluid Coupling Type
   - Torque Converter Type

**Fluid Coupling**

**Torque Converter**

# Transmission

## Components of Manual Transmission

Types of Clutches per Vehicle Model

*Dry Single Type (w/ Diaphragm)* – simple in structure and easy to operate. It efficiently discharges heat as the whole clutch is exposed to air and is most widely used at present.

| Model | Transmission | Clutch Type |
|---|---|---|
| Isuzu D-Max | MUA5H | Dry Single Plate w/ Diaphragm Spring |
| Isuzu mu-X | MUA5H | |
| Isuzu N-Series | MSB5S (NLR77)<br>MYY-5T (NLR85) | |

# Transmission

## Components of Manual Transmission

Types of Clutches per Vehicle Model

*Dry Type Multiple Disc Clutch* – It provides greater holding power than single disc clutch in cases where limited space prevents increase in clutch diameter. Mostly used in medium to heavy duty trucks, the use of additional plates increase clutch-to-plate area thus providing greater torque carrying capacity.

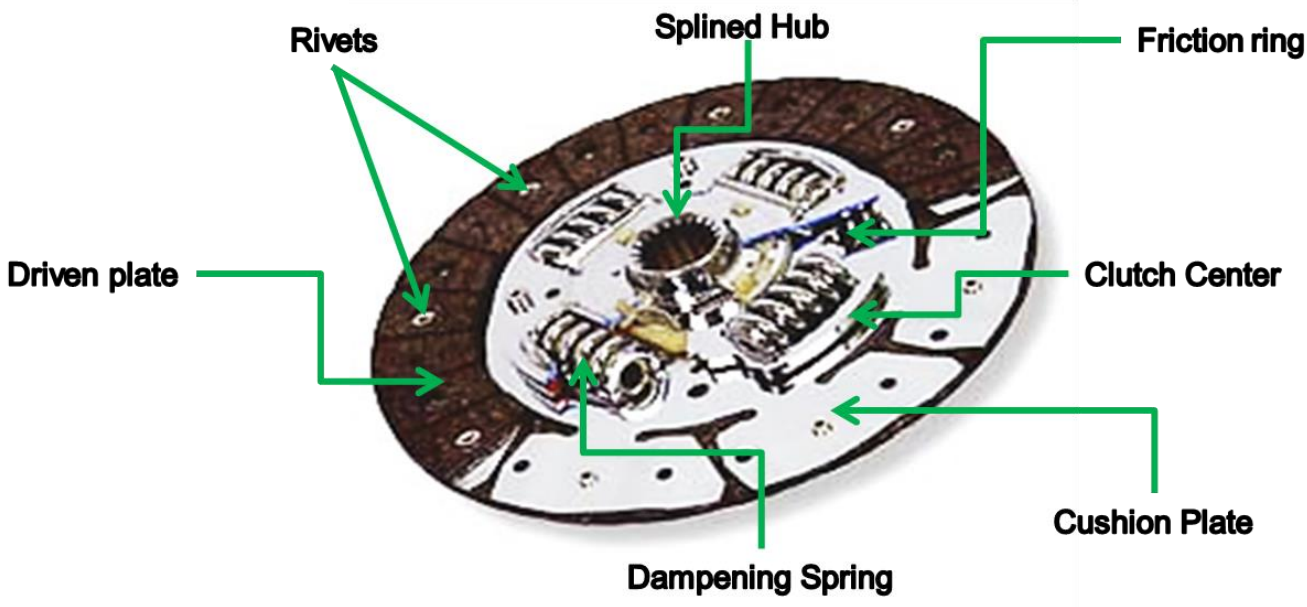
| Model | Transmission | Clutch Type |
|---|---|---|
| CYH | MJX16P | Dry Type Multiple Disc Clutch |
| EXZ | | |

# Transmission

## Components of Manual Transmission

Components of Clutch

Clutch Disc – It is a friction plate that transmits torque to the transmission through the input shaft. The friction material is riveted to both sides of the clutch plate. Damper springs and cushion plate are used to ensure smooth clutch engagement and prevent deformation of the clutch plate.



# Transmission

## Components of Manual Transmission

Components of Clutch

Clutch Cover Assembly – It consists of pressure spring or diaphragm spring, pressure plate, release lever, and strap plate.

- Mounted on the flywheel, it transmits torque by pressing the clutch against the flywheel through the pressure plate using the spring force of the pressure springs. It disengages torque by lifting the pressure plate by the operation of the release lever.

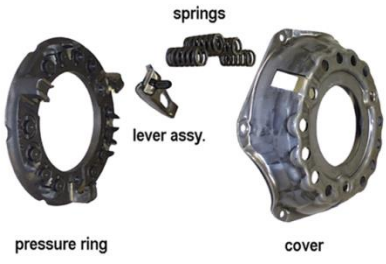
# Transmission

## Components of Manual Transmission

Components of Clutch

Types of Clutch Cover

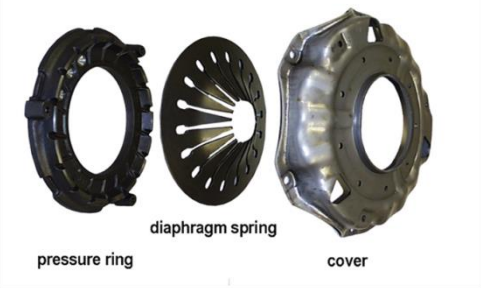
Coil Spring – It uses coil springs to press the clutch disc firmly against the flywheel. Typically used in most medium and heavy duty trucks due to large torque capacity.



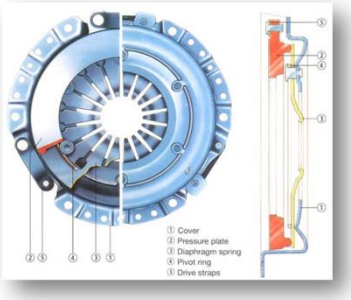

Exploded view of Coil Spring Plate

Coil Spring Plate

Diaphragm Spring – A simple one piece dish-shaped spring used to press the clutch to the flywheel. Mostly used in light duty trucks and passenger vehicles.




Exploded view of the Diaphragm Spring



# Transmission

## Components of Manual Transmission

Components of Clutch

Types of Clutch Cover

Strap Plate – It connects the clutch cover to the pressure plate. The tensile force of this plate transmits power while its flexure allows the pressure plate to move axially.

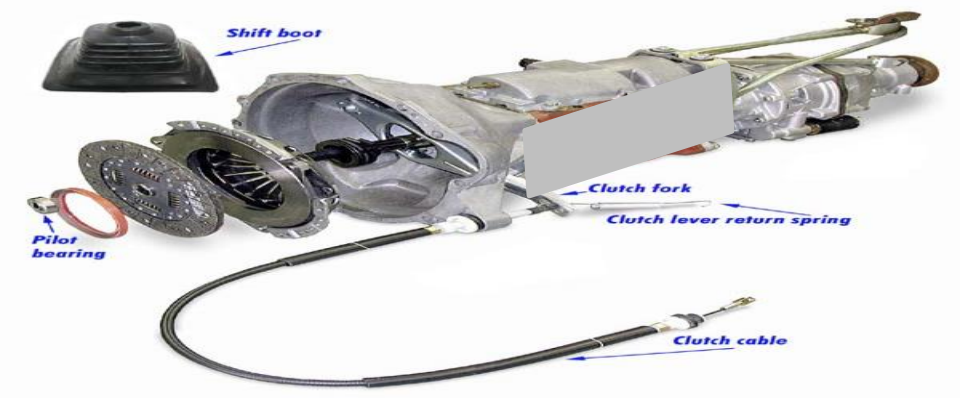
# Transmission

## Components of Manual Transmission

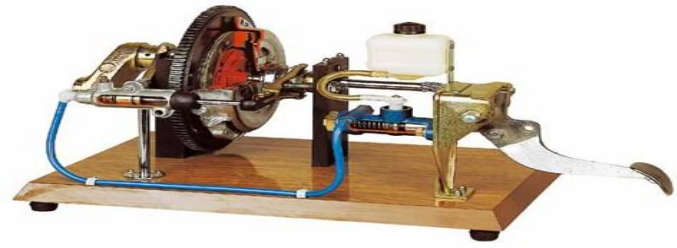
Components of Clutch

Clutch Control System

Cable Type – transmits clutch pedal motion to the clutch using a rod or cable wire. Simple in structure and easy to inspect.




Hydraulic Type – it engages the clutch by converting pedal motion to hydraulic pressure. Clutch boosters are used for large vehicles to reduce pedal effort



# Transmission

## Components of Manual Transmission

Components of Clutch

Clutch Pedal – Used to control the clutch engagement/disengagement by pressing or depressing the pedal.

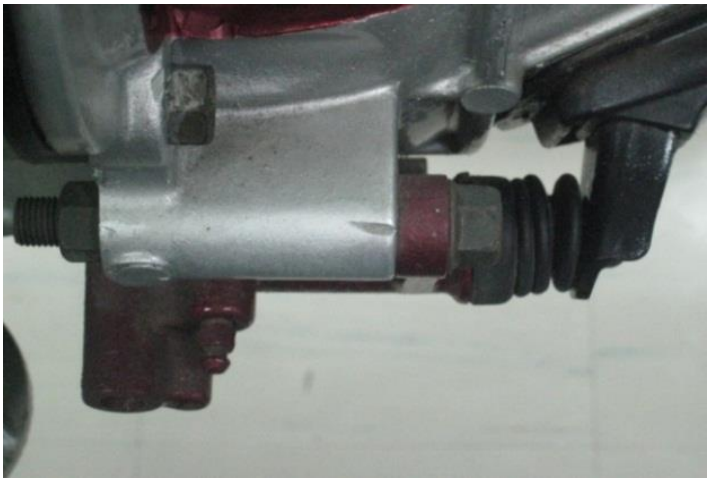
Master Cylinder – It converts driver's pedal motion into hydraulic pressure going to the slave cylinder.

# Transmission

## Components of Manual Transmission

Components of Clutch

Clutch Slave – it converts hydraulic pressure coming from the clutch master into mechanical motion of its piston to actuate the shift fork.



Clutch Booster – It reduces pedal effort by using compressed air to provide assist when clutch pedal is depressed. This is mainly used in medium and large trucks.

# Transmission

## Components of Manual Transmission

Components of Clutch

Release Bearing – Used to disengage the clutch from the flywheel by being pushed against the pressure plate.

Release Fork – it is controlled by the clutch pedal in the cabin and is what pushes the release bearing into the pressure plate fingers.

# Transmission

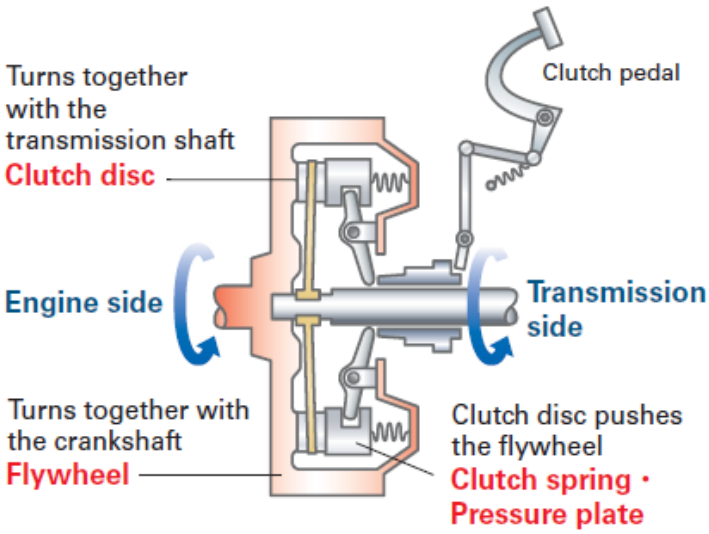
## Components of Manual Transmission

Function and Operation of Clutches

**Connecting clutch**

The condition when the clutch disc pushes the flywheel, with the force of the coil spring.

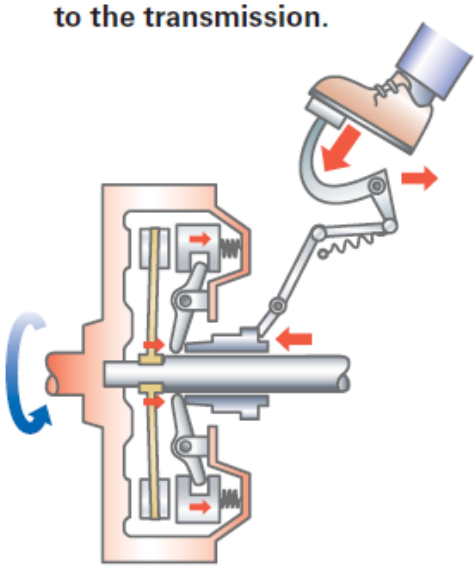
**Engine rotation is transmitted to the transmission.**




**Disengage clutch**

When stepping on the clutch pedal, a coil spring retracts and allows the clutch disc to separate from the flywheel.

**Engine rotation is not transmitted to the transmission.**

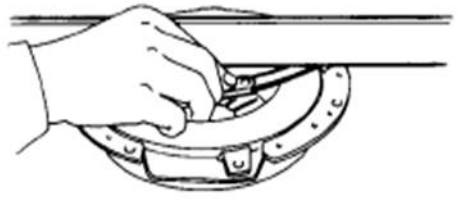


# Transmission

## Components of Manual Transmission

Basic Troubleshooting and Repair

Inspection of Clutch Cover



Pressure Plate Warpage


Checking Points

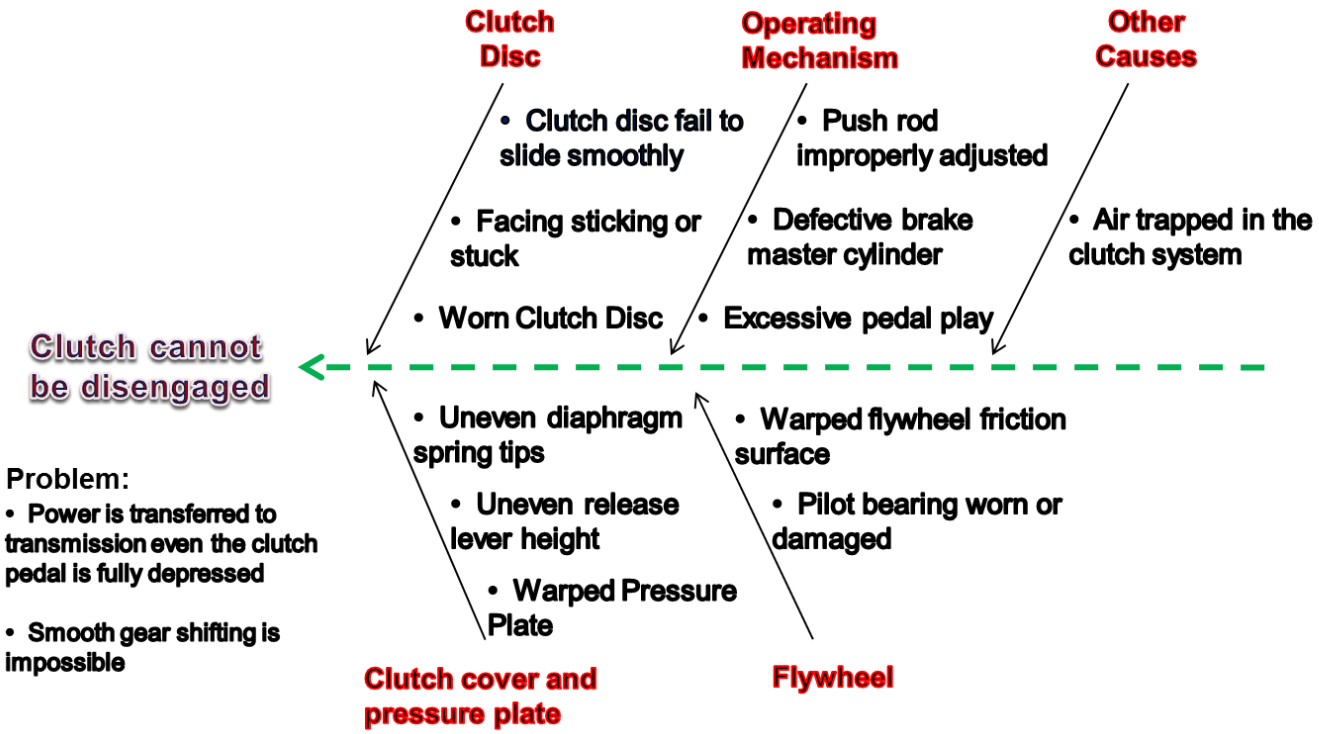
- Use a straight edge and a feeler gauge to measure the pressure plate friction surface flatness in two directions.

- Visually inspect the pressure plate friction for any excessive wear and heat cracks.

# Transmission

## Components of Manual Transmission

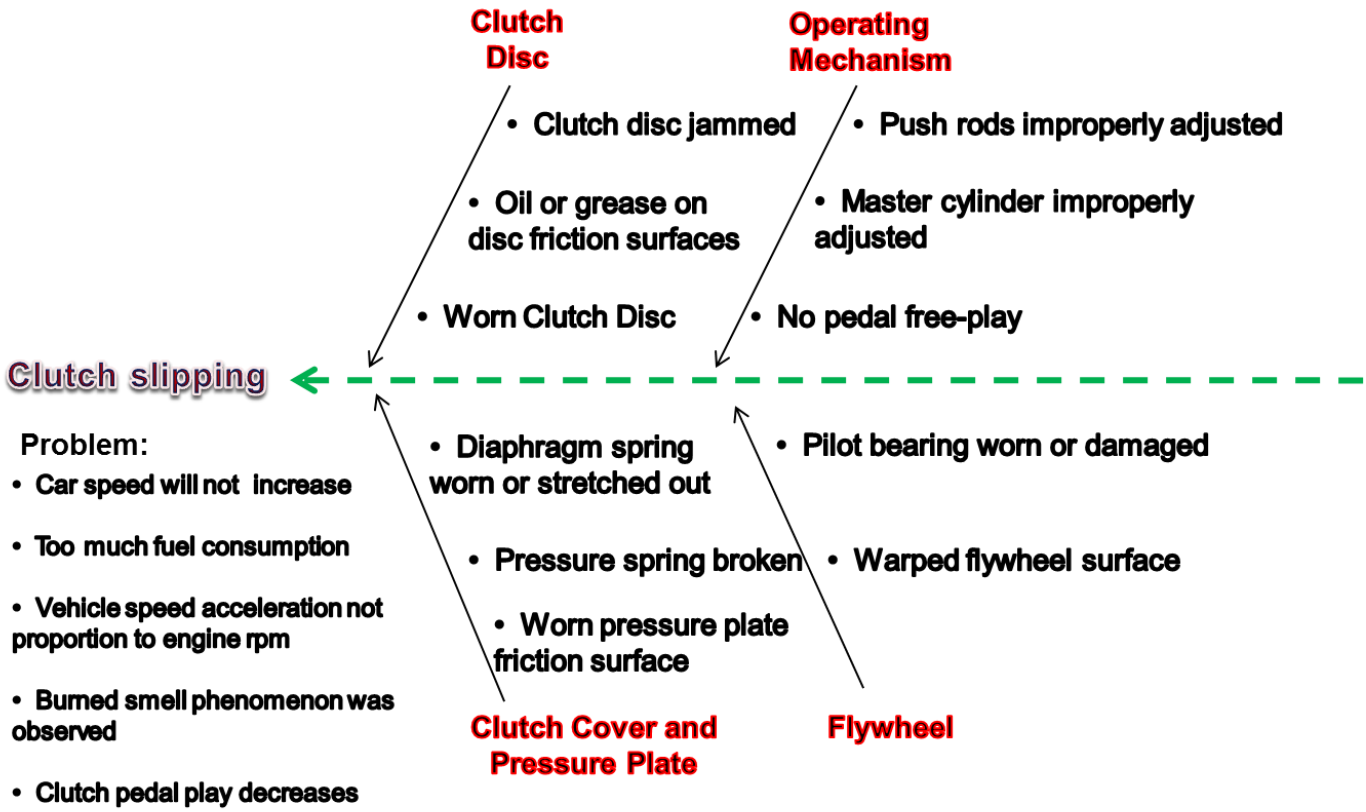
Basic Troubleshooting and Repair



# Transmission

## Components of Manual Transmission

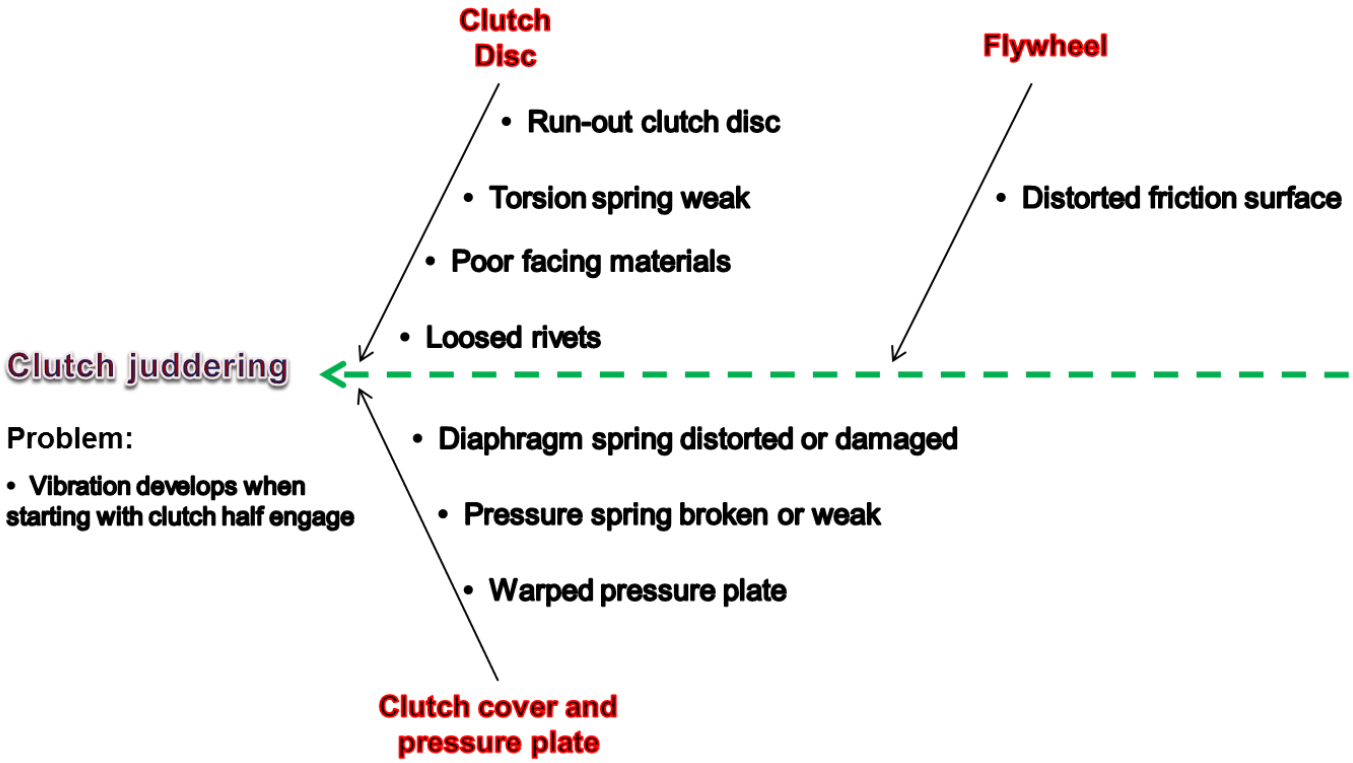
Basic Troubleshooting and Repair



# Transmission

## Components of Manual Transmission

Basic Troubleshooting and Repair

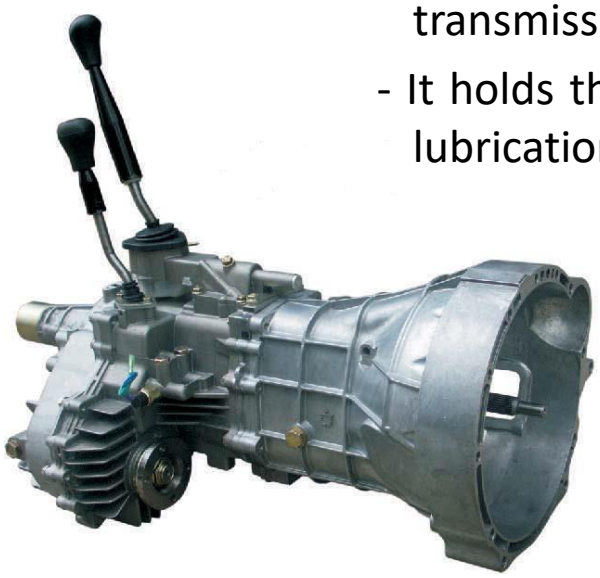


# Transmission

## Components of Manual Transmission

Transmission Case - It provides support for the bearing and shafts and other internal parts of the transmission.

- It holds the transmission oil, providing lubrication to the internal parts.



Extension Housing - It holds the transmission output shaft and rear oil seal.

- It has a flange at the bottom providing a base for the transmission mount.

# Transmission

## Components of Manual Transmission

Front Bearing Hub/Cap - It covers the front transmission bearing.

- Acts as a sleeve for the clutch release bearing.

Input Shaft - Transfers rotation from the clutch disc to the countershaft gears.

- The outer end is splined to hold the clutch disc.
- Inner end has a machined gear to rotate countershaft.
- Anytime the clutch disc turns, the input shaft and countershaft turns.

# Transmission

## Components of Manual Transmission

Countershaft - It holds the countershaft gears into mesh with input shaft and mainshaft gears.

Reverse Idler Shaft – It is a short shaft that supports the reverse idle gear.

- Installed in between countershaft and mainshaft, allowing the reverse idle gear to mesh on both shafts.

# Transmission

## Components of Manual Transmission

Mainshaft - Also called the output shaft, holds the mainshaft gears and synchronizers.

- It has splines which locks the synchronizers, but it lets the gears to rotate freely.
- Extends to the extension housing were it is connected to the propeller shaft.

Transmission Gears - Includes input gear, countershaft gears, mainshaft gears and reverse idler gear.

- If one of the mainshaft gears was locked by the synchronizer sleeve, the combination of input, countershaft and mainshaft gears create a specific gear ratio.


Counter Gear

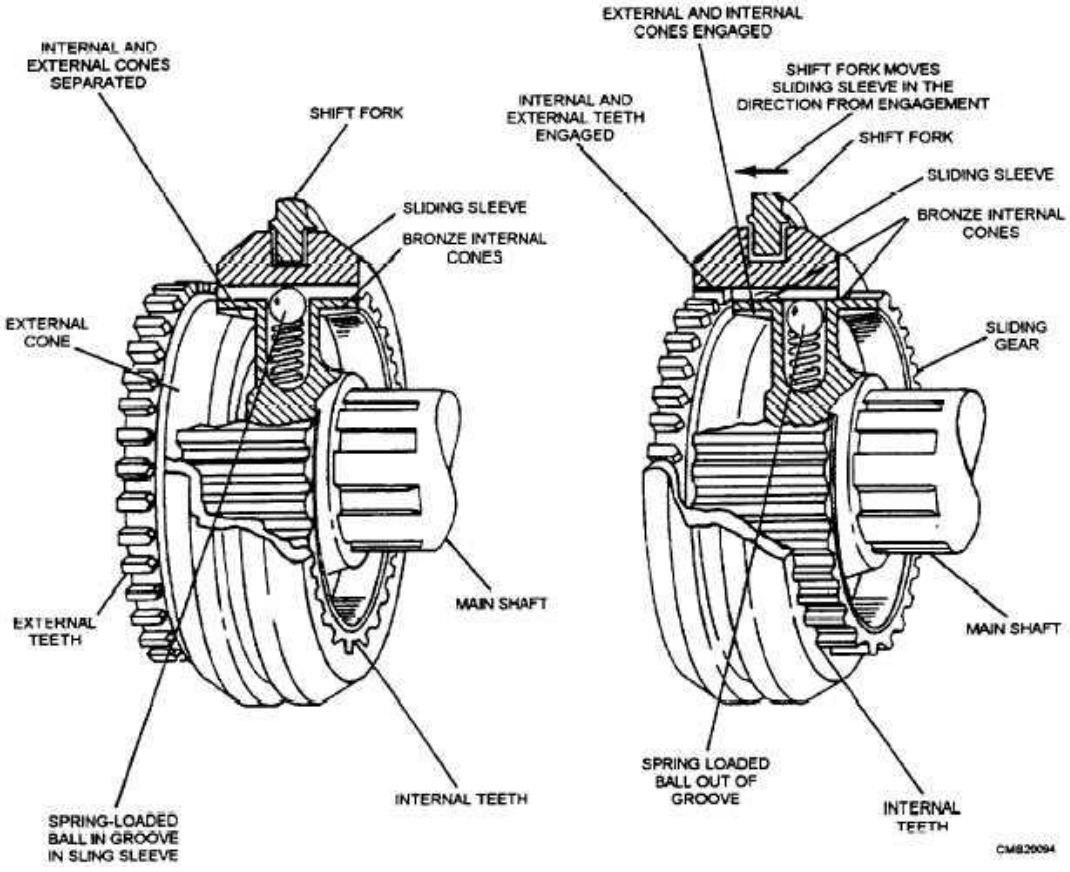
Main Gear

# Transmission

## Components of Manual Transmission

Synchronizer - It is a sleeve or drum that slides back and forth on the main shaft by shift fork during gear shift. It has two functions:

1. Lock the main shaft gear to the main shaft.
2. Prevent gear from clashing or grinding during shifting.



# Transmission

## Components of Manual Transmission

Shift Arm - It pushes the synchronizer into gear based from input coming from the shift lever.

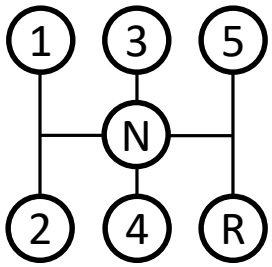
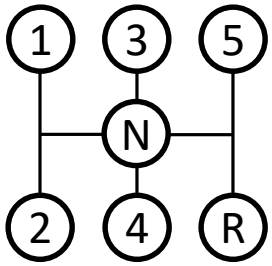
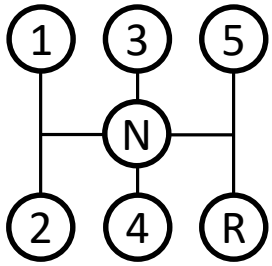
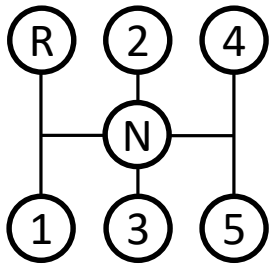
- It is connected to the shift lever via linkage rod or shift rail.

Shift Lever and Linkages - It is used to move the shift fork based from the driver's input.

- Has 2 types, Floor Mounted and Column Mounted.

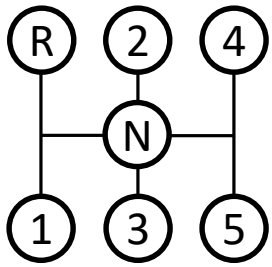
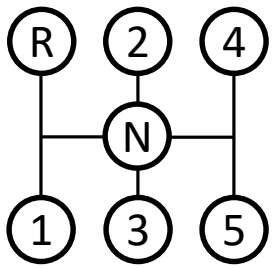
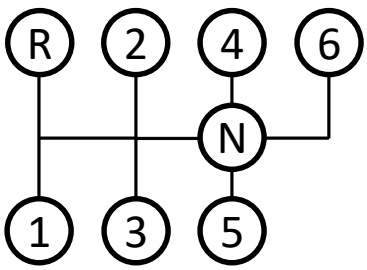
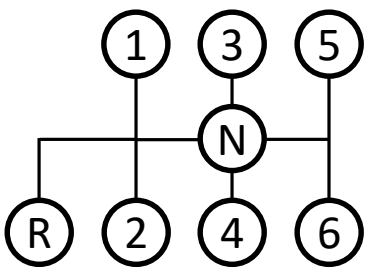
# Transmission

## Shift Pattern Per Vehicle Model

| Model | | Shift Pattern |
|---|---|---|
| Isuzu D-Max (MUA5H) |  |   |
| Isuzu QKR77 (MSB5S) |  |   |
| Isuzu NLR77 (MSB5S) |   |   |
| Isuzu NLR85 (MYY5M) |   |   |

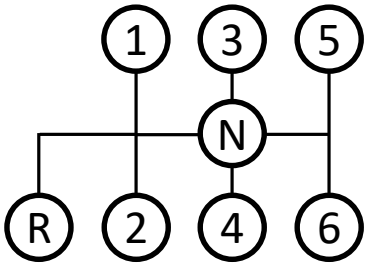
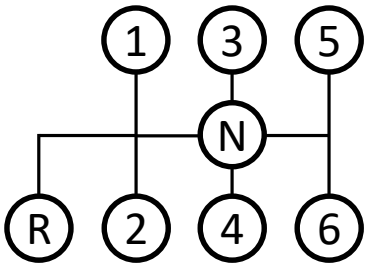
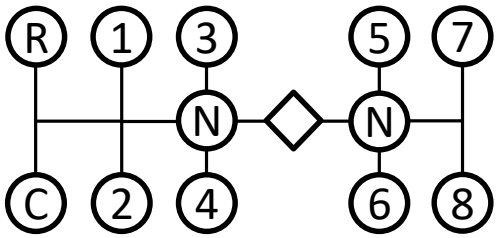
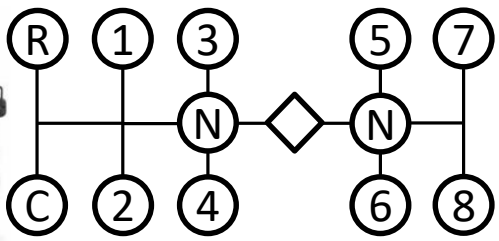
# Transmission

## Shift Pattern Per Vehicle Model

| Model | | Shift Pattern |
|---|---|---|
| Isuzu NMR85 (MYY5M) |   |   |
| Isuzu NPR85 (MYY5M) |   |   |
| Isuzu NQR75 (MYY6S) |   |   |
| Isuzu FRR90 (MZZ6W) |   |   |

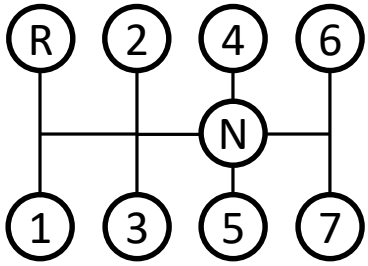
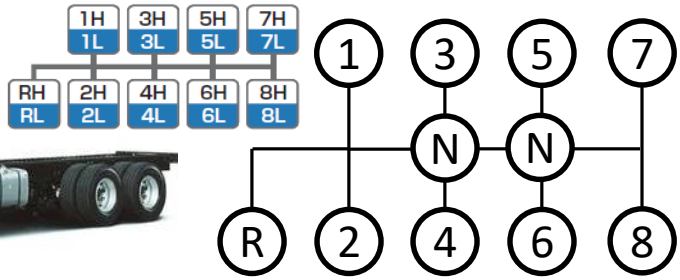
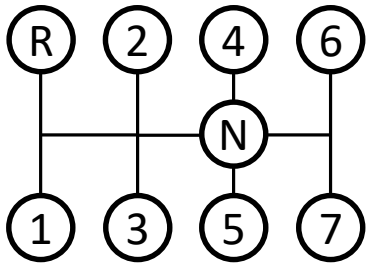
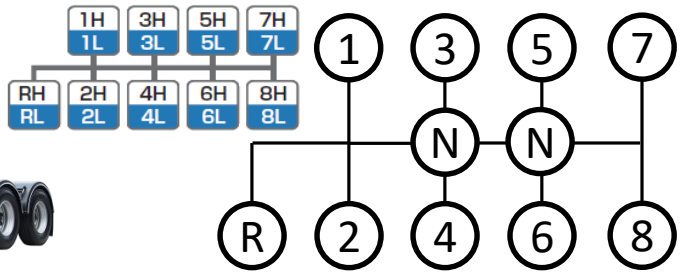
# Transmission

## Shift Pattern Per Vehicle Model

| Model | Shift Pattern |
|---|---|
| Isuzu FSR34 (MZW6P) |   |
| Isuzu FVR34 (MZW6P) |   |
| Isuzu FVM34T (ES11109) |   |
| Isuzu FVM34W (ES11109) |   |

# Transmission

## Shift Pattern Per Vehicle Model

| Model | | Shift Pattern |
|---|---|---|
| Isuzu CYZ52 (MJT7S) |  |   |
| Isuzu CYH52 (MJX16P) |  |   |
| Isuzu EXR52 (MJT7S) |  |   |
| Isuzu EXZ52 (MJX16P) |  |   |

# Transmission

## Fluid Capacities and Replacement Interval LCV

| Model | Transmission | Transmission Oil | Part No. | QTY | Replacement Interval |
|---|---|---|---|---|---|
| Isuzu D-Max | MUA 5H | Besco Transaxle Oil SAE 5W-30 | 1884057520 | 3.0 L | Every 20,000 Km |
| Isuzu mu-X EURO 2 | | | | | |


Isuzu D-Max


Isuzu mu-X

# Transmission

## Fluid Capacities and Replacement Interval CV

### For N-Series

| Model | Transmission | Transmission Oil | Part No. | QTY | Replacement Interval |
|---|---|---|---|---|---|
| NLR77 | MSB5S | IGMO XTRM 15W-40/ Besco 5W-30 | 570671459 /1884057520 | 2.7L | Every 20,000 Km |
| NLR85 | MYY5M | | | 2.8L | |
| NMR85 | | | | | |
| NPR85 | | | | | |
| NQR75 | MYY6S | | | 4.4L | |


# Transmission

## Fluid Capacities and Replacement Interval CV

### For F-Series

| Model | Transmission | Transmission Oil | Part No. | QTY | Replacement Interval |
|---|---|---|---|---|---|
| FRR90 | MZZ6W | DELO GL-5 (80W-90, 85W-40) | 510411H RK/5104 12HRK | 4.4L | Every 20,000 Km |
| FSR34 | MZW6P | | | 5.3L | |
| FVR34 | | | | | |
| FVM34 | Fuller ES11109 | | | 8.5L | |


# Transmission

## Fluid Capacities and Replacement Interval CV

### For C&E-Series

| Model | Transmission | Transmission Oil | Part No. | QTY | Replacement Interval |
|---|---|---|---|---|---|
| CYZ52 | MJT7S | DELO GL-5 (80W-90, 85W-40) | 510411H RK/5104 12HRK | 17.0L | Every 20,000 Km |
| EXR52 | | | | | |
| CYH52 | MJX16P | | | 19.0L | |
| EXZ52 | | | | | |

# Transmission

## Basic Troubleshooting for Manual Transmission

| Problem | Root Cause | Countermeasure |
|---|---|---|
| Abnormal Noises from Transmission | Insufficient/Bad Gear Oil | Refill/Replace |
| | Worn Flywheel Pilot Bearing | Replace |
| | Worn/Damaged Bearing | Replace |
| | Worn/Damaged Gear | Replace |
| | Worn Spline | Replace |
| | Gear or Bearing Thrust Scorched | Replace |
| | Inadequate Backlash on Gear Engagement | Replace |
| | Transmission Displacement | Adjust |

# Transmission

## Basic Troubleshooting for Manual Transmission

| Problem | Root Cause | Countermeasure |
|---|---|---|
| Difficult to Shift | Insufficient/Bad Gear Oil | Refill/Replace |
| | Clutch Pedal Play Failure | Adjust |
| | Worn/insufficient grease on shift lever sliding section | Repair/Replace/Apply Grease |
| | Worn on sliding section of Shift Block and Shift Rod | Replace worn-out part |
| | Worn Synchronizer Sleeve or Shift Arm Groove | Replace worn-out part |
| | Worn on Thrust Washer, Collar, or Gear Thrust Surface | Replace worn-out part |
| | Worn Synchronizer Components | Replace |

# Transmission

## Basic Troubleshooting for Manual Transmission

| Problem | Root Cause | Countermeasure |
|---|---|---|
| Falling Out of Gear | Worn on Shift Lever Sliding Section and excessive play | Replace worn-out part |
| | Detent Ball Spring deterioration or breakage | Replace |
| | Detent Ball Worn | Replace |
| | Worn on sliding section of Shift Block and Shift Rod | Replace worn-out part |
| | Worn Synchronizer Sleeve or Shift Arm Groove | Replace worn-out part |
| | Worn on Thrust Washer, Collar, or Gear Thrust Surface | Replace worn-out part |
| | Worn/Damaged Bearing | Replace |
| | Worn Spline | Replace |
| | Worn Synchronizer Components | Replace |

# Transmission

## Basic Troubleshooting for Manual Transmission

| Problem | Root Cause | Countermeasure |
|---|---|---|
| Oil Leakage From Transmission | Excessive amount of oil | Adjust |
| | Bad Oil | Replace |
| | Drain Plug or Filler Plug Loose | Tighten and add oil |
| | Gasket Damage | Replace |
| | Worn/Damage Oil Seal | Replace |

# Transmission

## Basic Troubleshooting for Manual Transmission

| Problem | Root Cause | Countermeasure |
|---|---|---|
| Clutch Slipping | No Clutch Pedal Play | Adjust |
| | Disproportionate Worn of Front Cover | Replace |
| | Worn/Adhesion of oil on Clutch Disc Facing | Clean/Replace |
| | Front Cover Oil Seal Failure | Replace |
| | Crankshaft Rear Oil Seal Failure | Replace |
| | Worn/Damaged Release Bearing | Replace |
| | Weak Diaphragm Spring/Worn Tip | Replace |

# Transmission

## Basic Troubleshooting for Manual Transmission

| Problem | Root Cause | Countermeasure |
|---|---|---|
| Release Failure in the Clutch | No Clutch Pedal Play | Adjust |
| | Oil Pressure Leakage | Repair |
| | Deformation of Clutch Disc | Replace |
| | Sticking of the Clutch Disc Spline | Apply Grease/Replace |
| | Worn/Sticking of input shaft spline | Apply Grease/Replace |
| | Pressure Plate/Flywheel Deformation | Repair/Replace |
| | Worn Flywheel Pilot Bearing | Replace |

# Transmission

## Basic Troubleshooting for Manual Transmission

| Problem | Root Cause | Countermeasure |
|---|---|---|
| Clutch Judder | Loose/Damaged Engine Mounting | Tighten/Replace |
| | Deformed Pressure Plate/Flywheel | Replace |
| | Deformed Clutch Disc Facing | Replace |
| | Worn/Adhesion of oil on Clutch Disc Facing | Clean/Replace |
| | Front Cover Oil Seal Failure | Replace |
| | Crankshaft Rear Oil Seal Failure | Replace |
| | Sticking of the Clutch Disc Spline | Apply Grease/Replace |
| | Worn/Sticking of input shaft spline | Apply Grease/Replace |

# Transmission

## Basic Troubleshooting for Manual Transmission

| Problem | Root Cause | Countermeasure |
|---|---|---|
| Abnormal Noises From Clutch | No Oil on Clutch Pedal Shaft | Repair/Replace |
| | No Oil on Master Cylinder Push Rod | Apply Grease |
| | Weak/Damaged Damper Spring | Replace Clutch Disc |
| | Worn Flywheel Pilot Bearing | Replace |

# Transmission

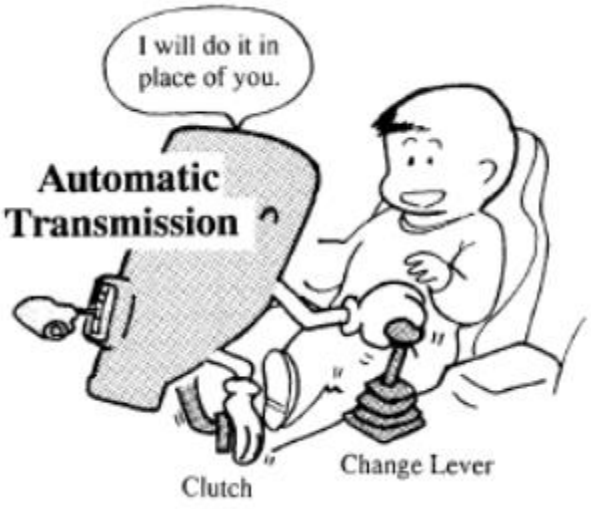
## Basic Troubleshooting for Manual Transmission

| Problem | Root Cause | Countermeasure |
|---|---|---|
| Clutch Fluid Leakage | Worn/Damaged Master Cylinder Cup | Replace |
| | Worn/Damaged Slave Cylinder Piston Cup | Replace |
| | Improper Connections of pipes or hoses | Tighten |

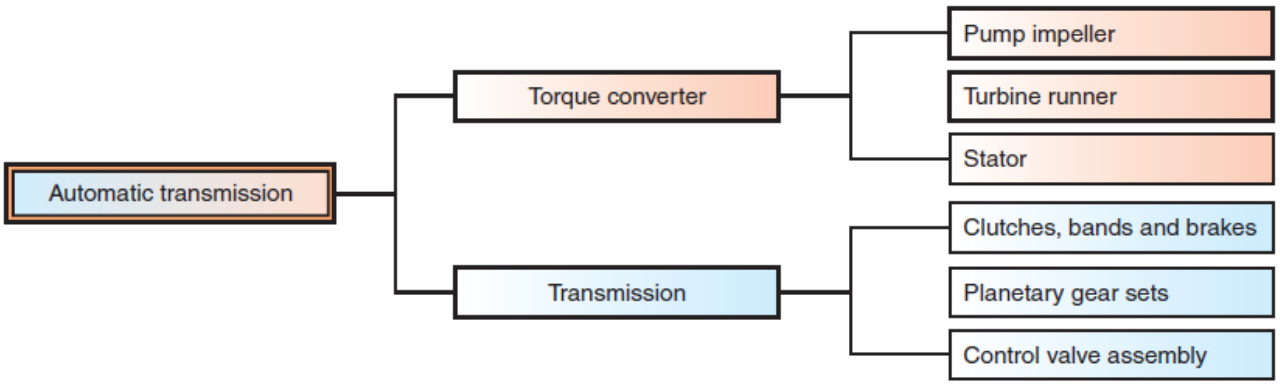
# Transmission

## Automatic Transmission

The automatic transmission is a device that shifts gears automatically based on vehicle driving conditions. It frees the driver of the responsibility of manually selecting gears as for the manual transmission.




Basic Parts of the Automatic Transmission

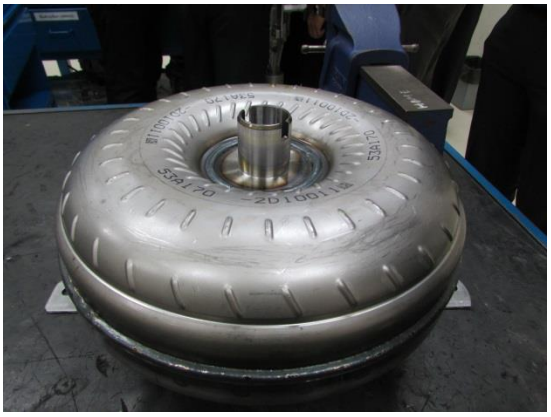


# Transmission

## Automatic Transmission

Components of Automatic Transmission

*Torque Converter* – It is a form of fluid coupling that uses fluid and vaned rotors to transmit power between shafts. It is filled with A/T Fluid which transmits power from the engine crankshaft to the transmission input shaft.



# Transmission

## Automatic Transmission

Components of Automatic Transmission

*Parts of the Torque Converter*

Pump Impeller – Driven by crankshaft via converter cover and gives velocity energy to the A/T fluid. It has a drive sleeve which powers the oil pump to supply hydraulic fluid to the entire automatic transmission.

Turbine Runner – It is driven by the fluid energy generated by the pump impeller using cup-shaped steel blades. A spline in its center is used to transmit engine power to the input shaft as it rotates.

# Transmission

## Automatic Transmission

Components of Automatic Transmission

*Parts of the Torque Converter*

*Stator* – It is placed in between the pump impeller and the turbine runner, providing torque multiplication as it directs fluid flow from impeller to turbine thus increasing the efficiency of the torque converter.

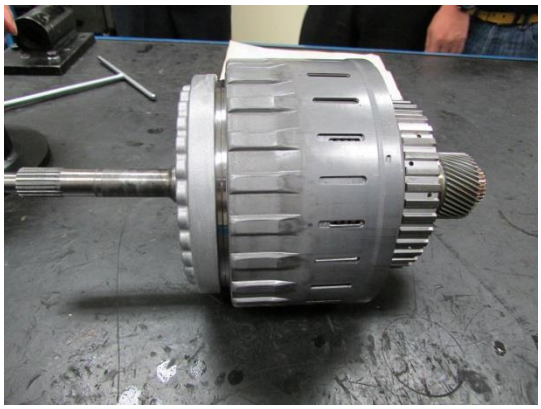
*Lock-up Clutch* – It connects the turbine to the converter cover, eliminating any slippage at higher speeds. This improves fuel economy and drivability of the vehicle as losses due to slippage are eliminated.

# Transmission

## Automatic Transmission

Components of Automatic Transmission

*Forward Clutch Assembly* – It transmits torque from the torque converter turbine to forward clutch pack. Has an o-ring to maintain A/T fluid pressure for torque converter lock-up operation.



*Oil Pump* – Provides oil pressure for various clutches and brakes and circulates lubrication to the entire automatic transmission including transmission cooler for ATF cooling.

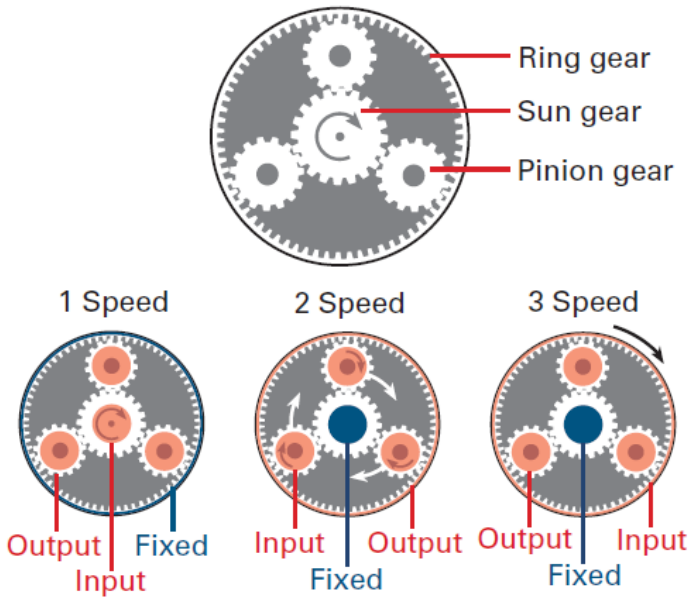
# Transmission

## Automatic Transmission

Components of Automatic Transmission

*Planetary Gear Assembly* – A set of gears assembled in a form that resembles a planetary system. It is composed of:

- Ring Gear
- Pinion Gear
- Sun Gear
- Planetary Carrier



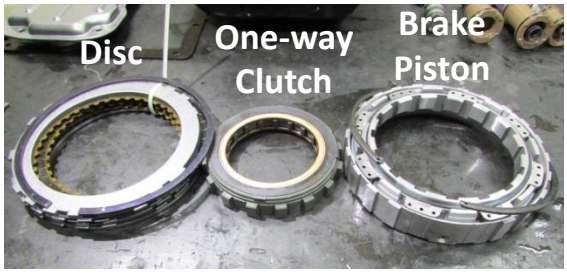
# Transmission

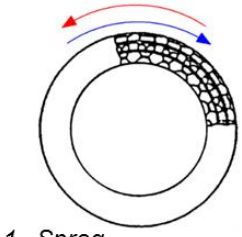
## Automatic Transmission

Components of Automatic Transmission

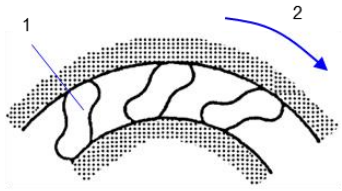
*Clutches and Brakes*

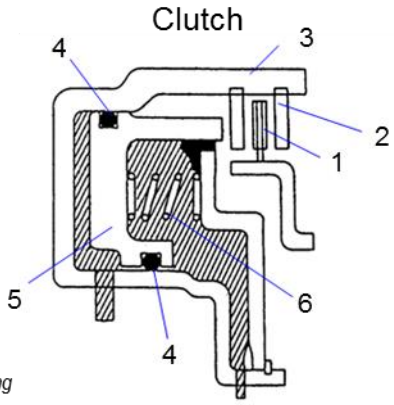
- Locks parts of the planetary gear assembly to the transmission case to create multiple gear ratios.
- They operate by means of pressure which is controlled by the TCM using solenoids.
- The One-way Clutch allows only one direction of rotation of parts that it controls in order to facilitate effective gear shifting, removing unnecessary gear movement during shift.

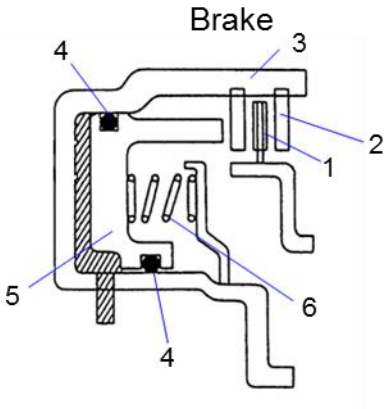


1. Sprag
2. Rotating direction




1. Disk
2. Plate
3. Drum
4. Oil seal
5. Piston
6. Return spring

# Transmission

## Automatic Transmission

Components of Automatic Transmission

*Input Shaft* A

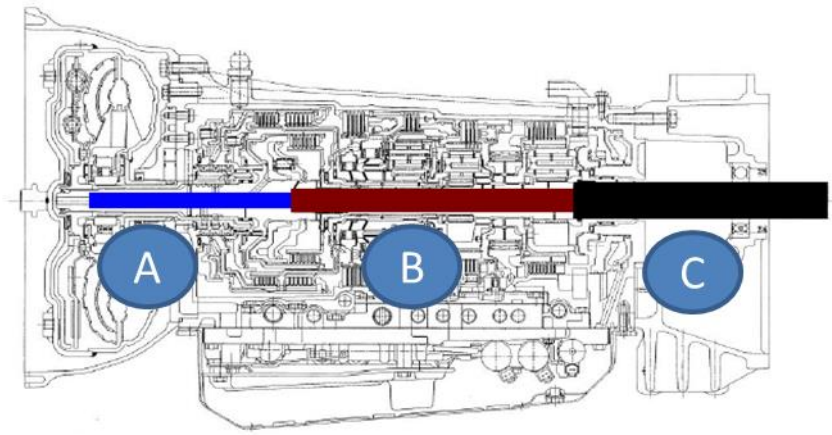
– Fitted to the turbine runner and forward clutch assembly by spline, it transmits torque coming from the engine to the clutch assy.

*Intermediate Shaft* B

– Fitted to the Forward Clutch and serves as the sun gear of middle and rear planetary gear sets.

*Output Shaft* C

– Transmits engine driving force from rear planetary carrier to propeller shaft



# Transmission

## Automatic Transmission

Components of Automatic Transmission

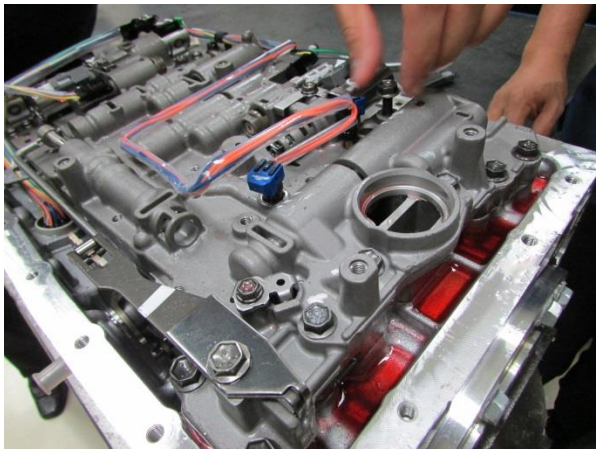
*Control Valve Assembly (Valve Body)*

- It directs A/T fluid flow to different passages, ports, drains, springs and valves for the purpose of:

- *Shift Timing*
- *Shift Speed*
- *Shift Quality*

Can be of two types

- *Regulates oil pressure and flow*
- *Regulates oil flow direction*



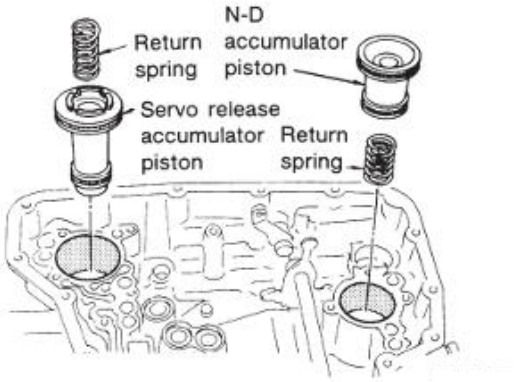
# Transmission

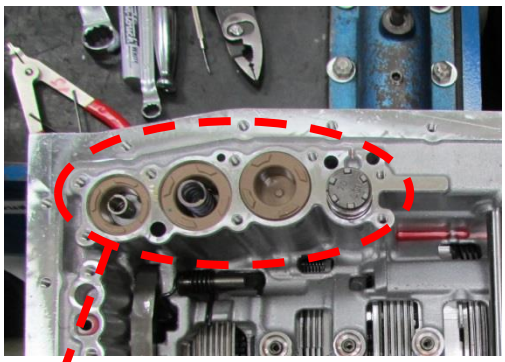
## Automatic Transmission

Components of Automatic Transmission

*Accumulators*

- Allows pressure to build more slowly to cushion the shift shock for smooth shifting.



# Transmission

## Automatic Transmission

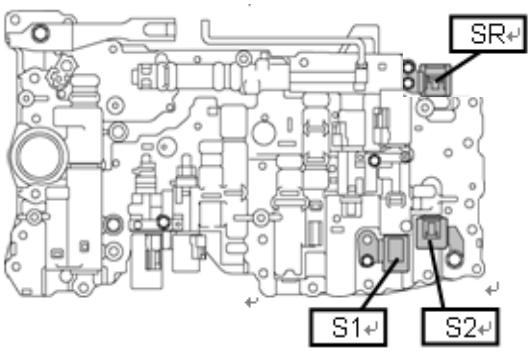
Components of Automatic Transmission

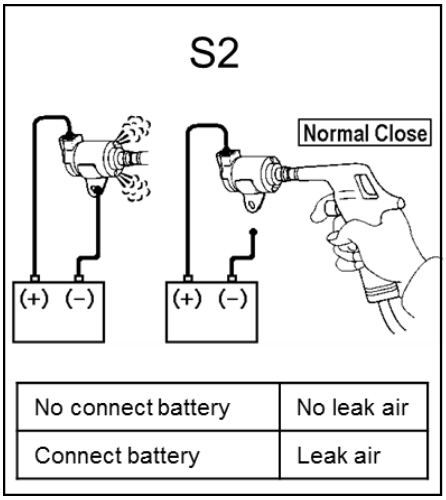
*Solenoids*

- These are electronically controlled valves fitted in the valve body that directs A/T fluid flow to various clutches and brakes in order to create a certain gear ratio.

Examples of Solenoids (TB50LS):

- Shift Solenoids
- Line Pressure Control Solenoid
- Clutch Pressure Control Solenoid
- Lock-up Control Solenoid



# Transmission

## Automatic Transmission

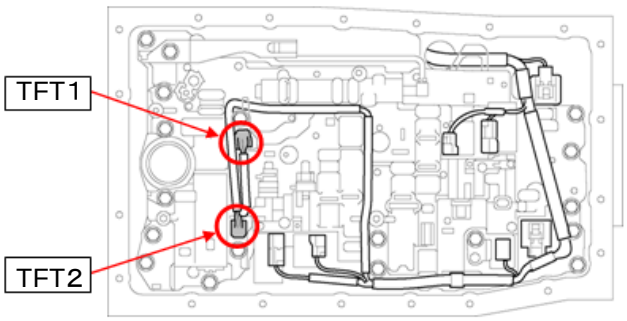
Components of Automatic Transmission

*Sensors*

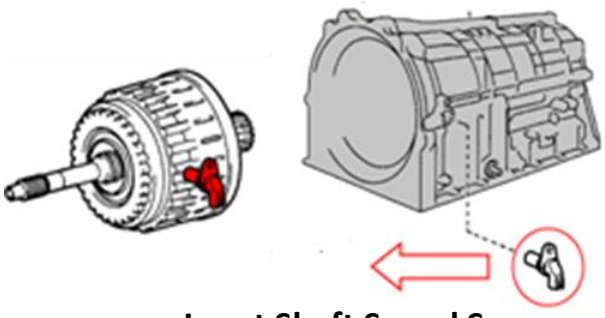
- It detects movements and conditions of various transmission parts and sends it to the Transmission Control Module as input in order to effect control.

Examples of Sensors (TB50LS):

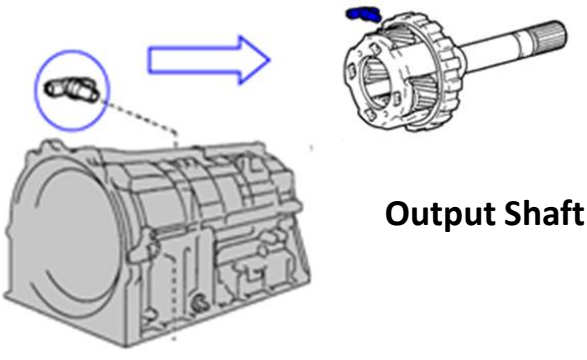
- Transmission Fluid Temperature Sensor 1 & 2
- Input and Output Shaft Speed Sensor




**Transmission Fluid Temperature Sensor**



**Input Shaft Speed Sensor**



**Output Shaft Speed Sensor**

# Transmission

## Automatic Transmission

Components of Automatic Transmission

*Switches*

- It provides input signal to the Transmission Control Module in terms of position of shift lever or operation of related vehicle parts including brake pedal as part of effecting transmission control.

Examples of Switches (TB50LS):

- Transmission Range Switch
- Brake Pedal Switch

*Select Lever*

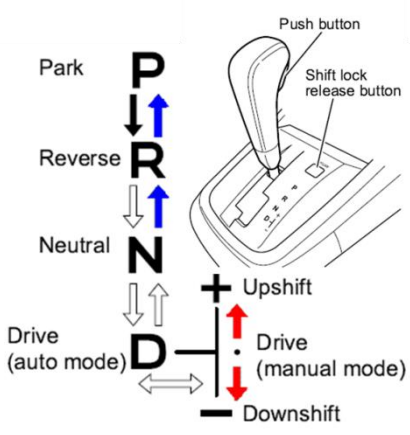
- Driver operated lever which transmits gear position via connecting cable to the TR switch.

Operate the selector lever while pressing the push button with the brake pedal pressed.

Operate the selector lever while pressing the push button.

Operate the selector lever without pressing the push button.

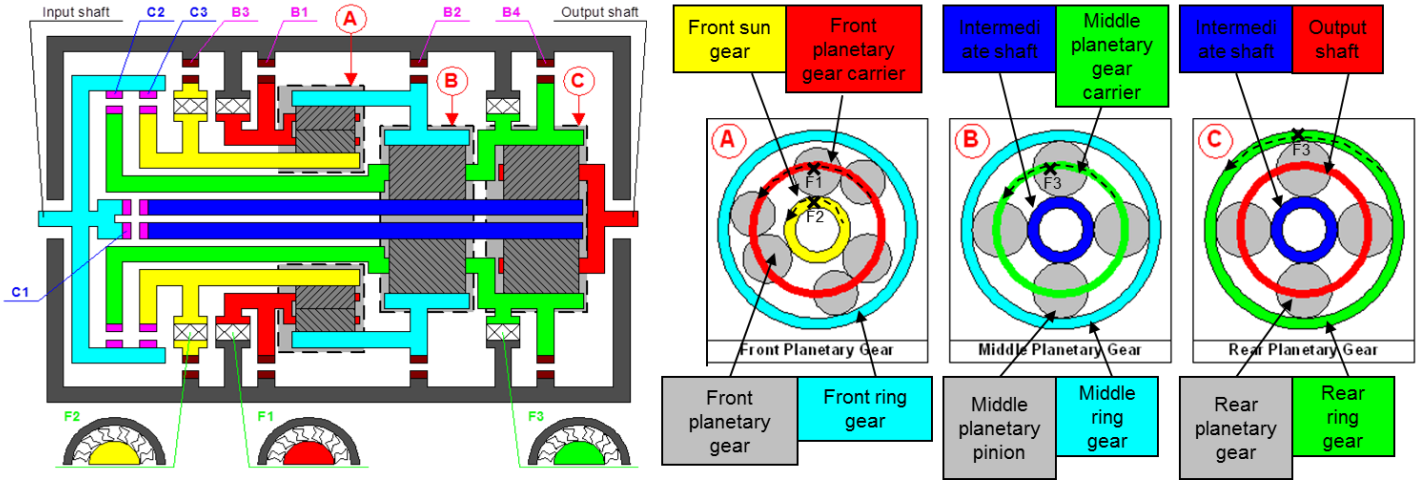
Operate the selector lever without pressing the push button. The selector lever will return to the manual mode position when you release your hand after operating the lever in the direction of the arrow.



# Transmission

## Automatic Transmission

### Shifting Pattern (for TB50LS)




| COMPONENT | | FUNCTION |
|---|---|---|
| C1 | Clutch No.1 | Connect input shaft to intermediate shaft. |
| C2 | Clutch No.2 | Connect input shaft to middle planetary gear carrier. |
| C3 | Clutch No.3 | Connect input shaft to front sun gear. |
| B1 | Brake No.1 | Lock front planetary gear carrier. |
| B2 | Brake No.2 | Lock front & middle ring gear. |
| B3 | Brake No.3 | Lock outer race of one-way clutch No.2 (F2). |
| B4 | Brake No.4 | Lock middle planetary gear carrier and rear ring gear. |
| F1 | One-way clutch No.1 | Lock counterclockwise rotation of front planetary carrier. |
| F2 | One-way clutch No.2 | Lock counterclockwise rotation of front sun gear, when B3 operations. |
| F3 | One-way clutch No.3 | Lock counterclockwise rotation of rear ring gear. |

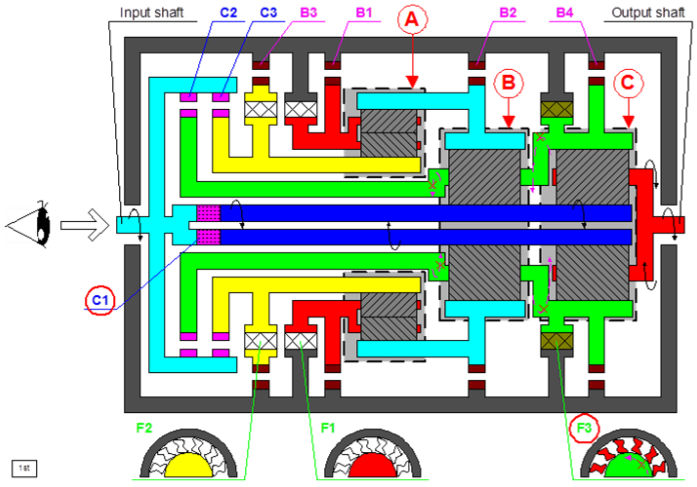
# Transmission

## Automatic Transmission

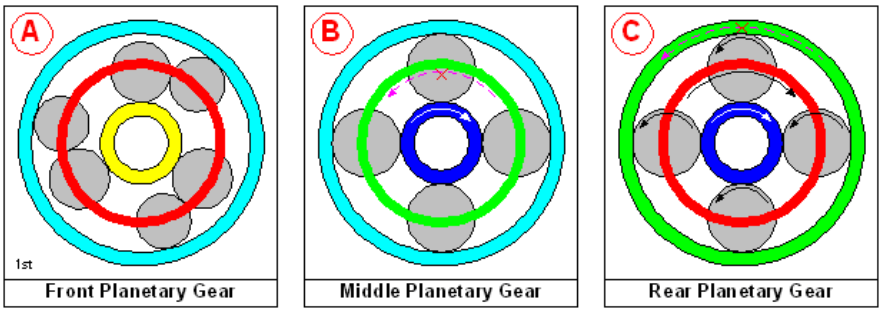
Shifting Pattern (for TB50LS)

**"D" Range – 1st Gear**

| POSITION | | Solenoid | | | | | | Clutch | | | Brake | | | | One-way clutch | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | S1 | S2 | SR | SL1 | SL2 | SLU | C1 | C2 | C3 | B1 | B2 | B3 | B4 | F1 | F2 | F3 |
| D | 1st | ON | OFF | OFF | OFF | ON | OFF | ON | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | ON |




- Input shaft rotates clockwise.
  - C1 operates (Connect input shaft to intermediate shaft).
- Intermediate shaft rotates clockwise.
- Rear sun gear rotates clockwise.
- Rear planetary pinion rotates counterclockwise.
- Rear ring gear is going to rotate counterclockwise.
  - F3 operates (Lock counterclockwise rotation of rear carrier).
- Rear planetary carrier rotates clockwise.
- Output shaft rotates clockwise.



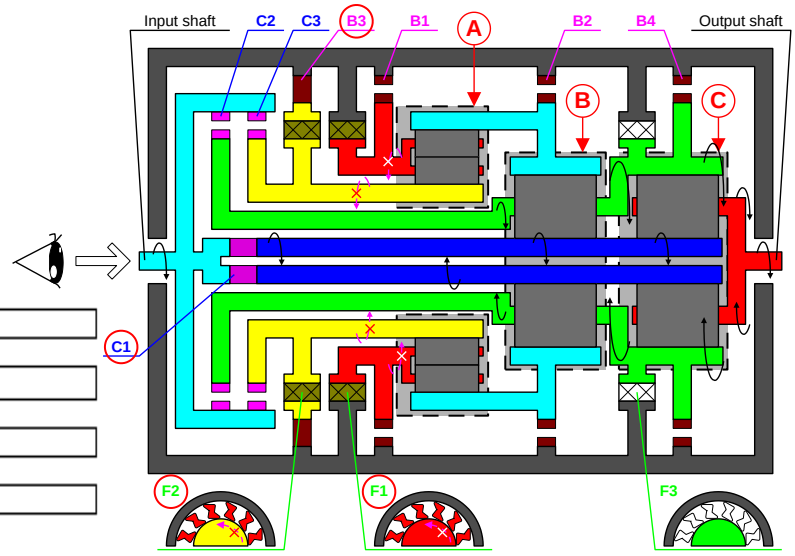
# Transmission

## Automatic Transmission

Shifting Pattern (for TB50LS)

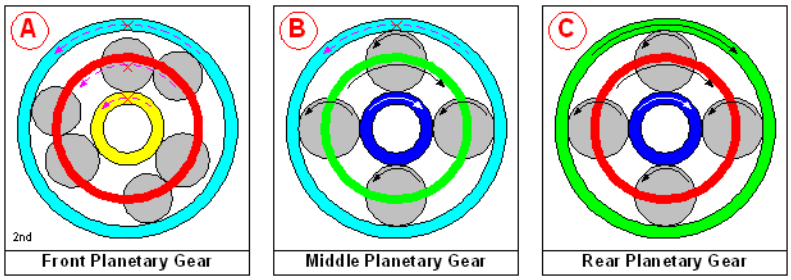
**"D" Range – 2nd Gear**

| POSITION | | Solenoid | | | | | | Clutch | | | Brake | | | | One-way clutch | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | S1 | S2 | SR | SL1 | SL2 | SLU | C1 | C2 | C3 | B1 | B2 | B3 | B4 | F1 | F2 | F3 |
| D | 2nd | ON | ON | OFF | OFF | ON | X | ON | OFF | OFF | OFF | OFF | ON | OFF | ON | ON | OFF |




- Input shaft rotates clockwise.
  - C1 operates (Connect input shaft to intermediate shaft)
- Intermediate shaft rotates clockwise.
  - Middle sun gear rotates clockwise.
    - Middle planetary pinion rotates counterclockwise.
      - B3, F2 and F1 operated. (Middle ring gear and front ring gear are going to rotates counterclockwise, but lock them)
    - Middle planetary carrier rotates clockwise
    - Rear ring gear rotates clockwise.
  - Rear sun gear rotates clockwise.
- Rear planetary carrier rotates clockwise

  Rear sun gear rotation speed - Rear ring gear rotation speed = Rear planetary carrier rotation speed
- Output shaft rotates clockwise.



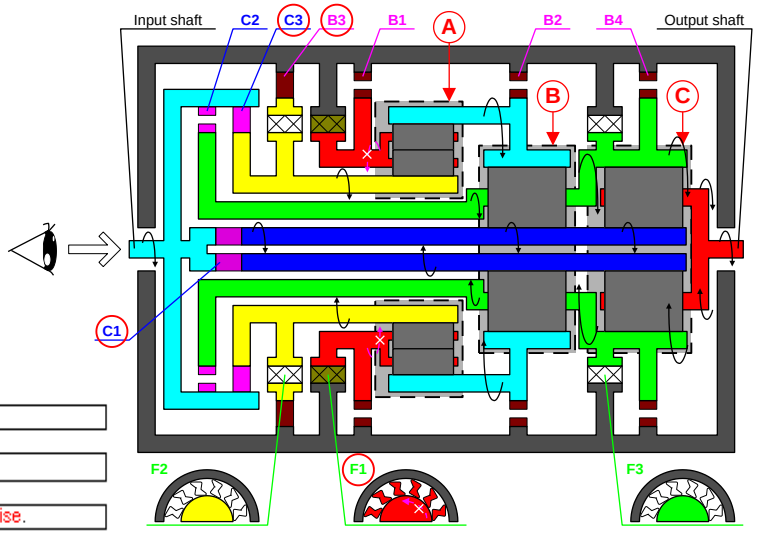
# Transmission

## Automatic Transmission

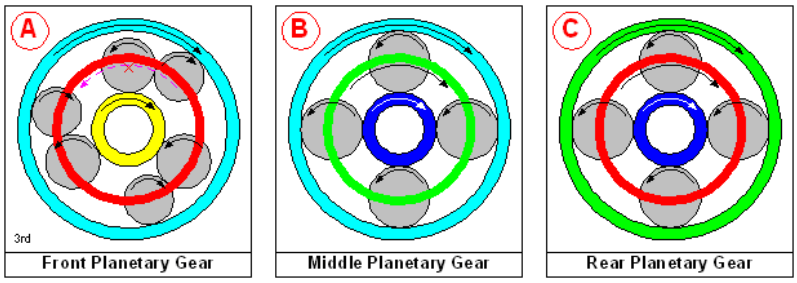
Shifting Pattern (for TB50LS)

**"D" Range – 3rd Gear**

| POSITION | | Solenoid | | | | | | Clutch | | | Brake | | | | One-way clutch | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | S1 | S2 | SR | SL1 | SL2 | SLU | C1 | C2 | C3 | B1 | B2 | B3 | B4 | F1 | F2 | F3 |
| D | 3rd | OFF | ON | OFF | OFF | ON | X | ON | OFF | ON | OFF | OFF | ON | OFF | ON | OFF | OFF |




- Input shaft rotates clockwise.
  - C3 operates
    - Front sun gear rotates clockwise.
      - Front inner planetary pinion rotates counterclockwise.
      - Front outer planetary pinion rotates clockwise.
        - F1 operates. (Lock counterclockwise rotation of front planetary carrier)
          - Front ring gear rotates clockwise.
            - Middle ring gear rotates clockwise.
              - Middle planetary carrier rotates clockwise.
                Middle sun gear rotation speed - middle ring gear rotation speed = Middle planetary carrier rotation speed
                - Rear ring gear rotates clockwise.
                  - Rear planetary carrier rotates clockwise.
                    Rear sun gear rotation speed - Rear ring gear rotation speed = Rear planetary carrier rotation speed
                    - Output shaft rotates clockwise.
  - C1 operates
    - Intermediate shaft rotates clockwise.



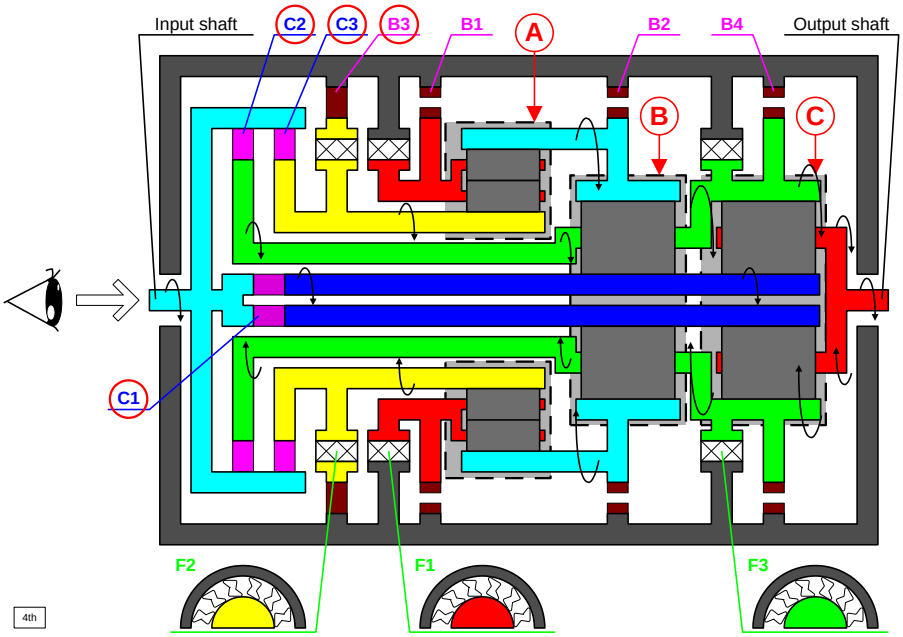
# Transmission

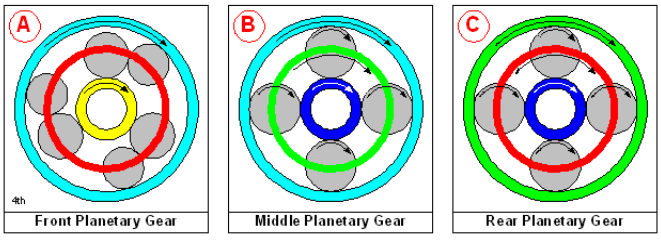
## Automatic Transmission

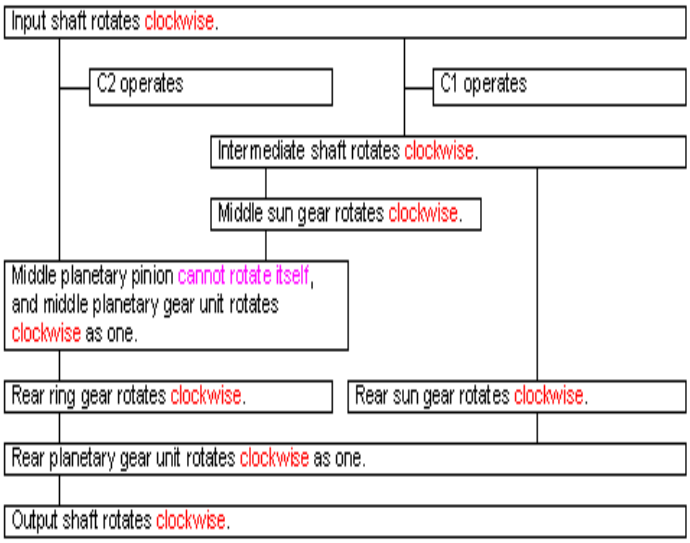
Shifting Pattern (for TB50LS)

**"D" Range – 4th Gear**

| POSITION | | Solenoid | | | | | | Clutch | | | Brake | | | | One-way clutch | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | S1 | S2 | SR | SL1 | SL2 | SLU | C1 | C2 | C3 | B1 | B2 | B3 | B4 | F1 | F2 | F3 |
| D | 4th | OFF | OFF | OFF | OFF | ON | X | ON | ON | ON | OFF | OFF | ON | OFF | OFF | OFF | OFF |



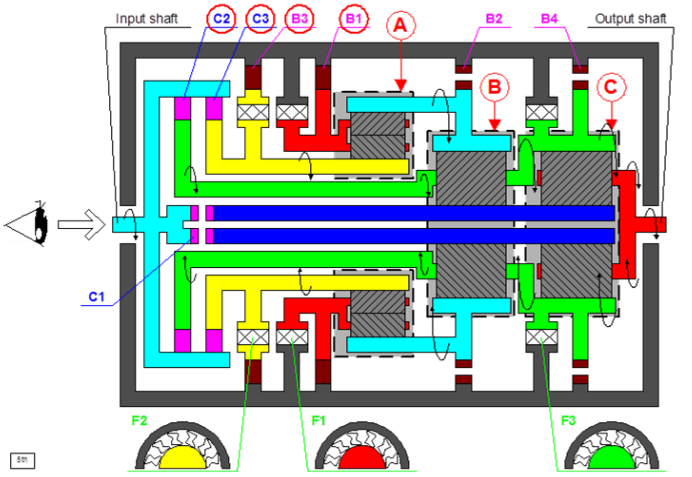
# Transmission

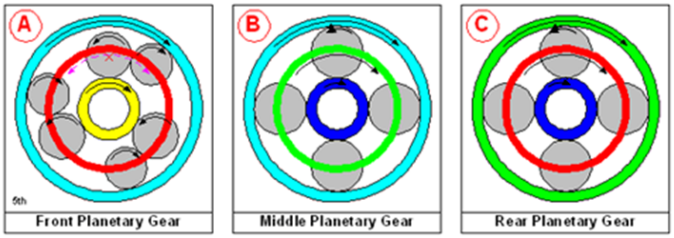
## Automatic Transmission

Shifting Pattern (for TB50LS)

**"D" Range – 5th Gear**

| POSITION | | Solenoid | | | | | | Clutch | | | Brake | | | | One-way clutch | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | S1 | S2 | SR | SL1 | SL2 | SLU | C1 | C2 | C3 | B1 | B2 | B3 | B4 | F1 | F2 | F3 |
| D | 5th | OFF | OFF | ON | ON | OFF | X | OFF | ON | ON | ON | OFF | ON | OFF | OFF | OFF | OFF |




Input shaft rotates clockwise.

- C3 operates
  - Front sun gear rotates clockwise.
  - Front inner planetary pinion rotates counterclockwise.
  - Front outer planetary pinion rotates clockwise.
    - B1 operates (Lock rotation of front planetary carrier)
  - Front ring gear rotates clockwise.
  - Middle ring gear rotates clockwise.
- C2 operates
  - Middle planetary carrier rotates clockwise.

Middle planetary pinion rotates counterclockwise

Middle ring gear rotation speed - Middle planetary carrier rotation speed = Middle planetary pinion rotation speed

Middle sun gear rotates clockwise.

Rear sun gear rotates clockwise.

Rear ring gear rotates clockwise.

Rear planetary carrier rotates clockwise.

Rear sun gear rotation speed - Rear ring gear rotation speed = Rear planetary carrier rotation speed

Output shaft rotates clockwise.

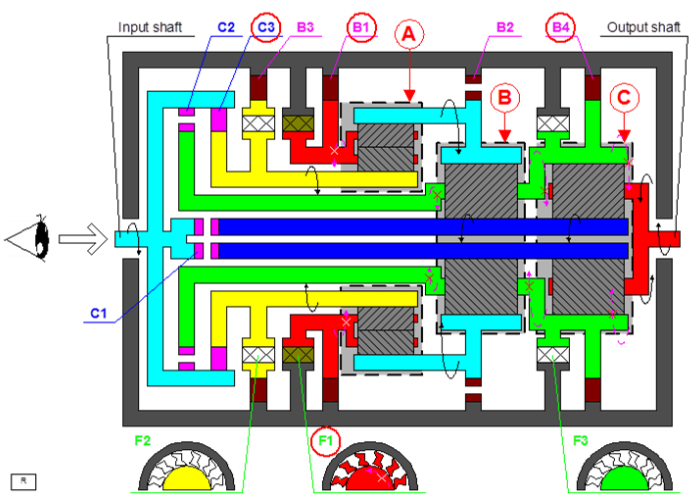
# Transmission

## Automatic Transmission

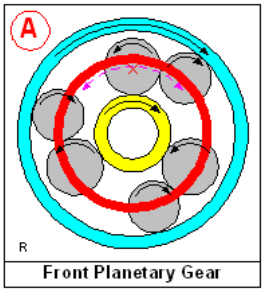
Shifting Pattern (for TB50LS)

**"R" Range Gear**

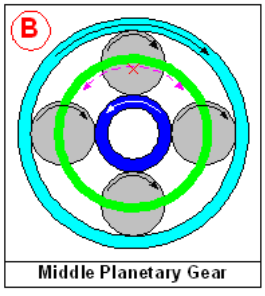
| POSITION | Solenoid | | | | | | Clutch | | | Brake | | | | One-way clutch | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S1 | S2 | SR | SL1 | SL2 | SLU | C1 | C2 | C3 | B1 | B2 | B3 | B4 | F1 | F2 | F3 |
| R | ON | OFF | OFF | OFF | ON | OFF | OFF | OFF | ON | ON | OFF | OFF | ON | ON | OFF | OFF |



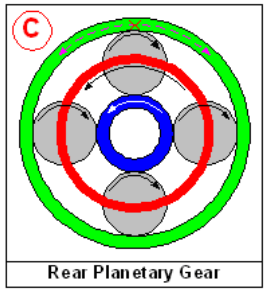

- Input shaft rotates clockwise.
  - C3 operates
- Front sun gear rotates clockwise.
- Front inner planetary pinion rotates counterclockwise.
- Front outer planetary pinion rotates clockwise.
  - B1 operates (Lock rotation of front planetary carrier)
- Front ring gear rotated clockwise.
- Middle ring gear rotates clockwise.
  - B4 operates (Lock rotation of middle planetary carrier and rear ring gear)
- Middle planetary pinion rotates itself clockwise.
- Middle sun gear rotates counterclockwise.
- Rear sun gear rotates counterclockwise.
  - B4 operates (Lock rotation of middle planetary carrier and rear ring gear)
- Rear planetary pinion rotates itself clockwise.
- Rear planetary carrier rotates counterclockwise.
- Output shaft rotates counterclockwise.



Front Planetary Gear



Middle Planetary Gear



Rear Planetary Gear

# Transmission

## Automatic Transmission

### Standard Fluids and Lubricants

| S/N | SERVICE ITEM | First 1.5K | every 5K | every 10K | every 20K |
|---|---|---|---|---|---|
| 14 | Clutch fluid | I | I | I | R |
| 15 | Clutch pedal travel and free play | I | I | I | I |
| 16 | Clutch system | I | I | I | I |
| 17 | [M/T] Manual transmission oil | R | - | - | R |
| 18 | [4WD M/T] Transfer case oil | - | - | - | R |
| 19 | [4WD M/T] Manual transmission and transfer case oil leakage | I | I | I | I |
| 20 | [A/T] Automatic transmission fluid | I | I | I | R |
| 21 | [A/T] Automatic transmission fluid filter (JR405 Transmission) | C – EVERY 60K | | | |

| | Model | SYSTEM | BRAND / SPECIFICATION | PART NO. | SUPPLY FORM | CAPACITY |
|---|---|---|---|---|---|---|
| 1 | Isuzu Crosswind | AW03-72LE | TEXAMATIC 1888 | As per assigned area | Liters | 3.0 L |
| 2 | Isuzu D-Max/Alterra | JR405 | TEXAMATIC 1888 | As per assigned area | Liters | 3.0 L |
| 3 | Isuzu D-Max/mu-X | TB50LS | Mobil AT3309 | SOTFR00061L | Quarts | 10.2L(Overhauling) 2.9L (Change Oil) |
| 4 | Isuzu mu-X Euro IV | AWR6B45 | ENEOS (JX NWS-9638) | 5877030010 | Liters | 3.0 L |

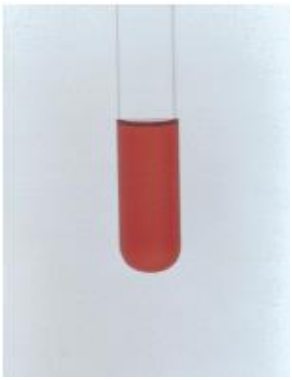
# Transmission

## Automatic Transmission

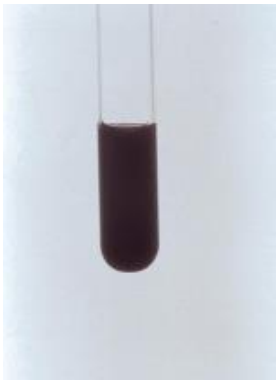
Inspection and Maintenance

Condition of Automatic Transmission Fluid

- Visually inspect condition of ATF
- If the ATF smells burnt out, replace it and investigate the cause of trouble.



New
A/T fluid



Deteriorated
A/T fluid

| Color of ATF | Condition |
|---|---|
| Clear Red | Normal |
| Blackish discoloration | Defects of power train parts (clutches) |
| White turbidity | Include water |
| Discoloration of red brown | Deterioration of ATF |

# Transmission

## Automatic Transmission

Basic Troubleshooting and Repair

Problem: Vehicle does not move in any forward ranges (or reverse)

| Checkpoint | Trouble Cause | Countermeasures |
|---|---|---|
| Manual Linkage | Manual linkage out of adjustment | Adjust linkage |
| Valve Body | Valve body or primary regulator faulty | Inspect valve body |
| Torque Converter | Torque converter faulty | Replace torque converter |
| Oil Pump | Oil pump intake screen blocked | Clean screen |
| Transmission | Transmission faulty | Disassemble and inspect transmission |

# Transmission

## Automatic Transmission

Basic Troubleshooting and Repair

Problem: Slips on 1-2, 2-3, 3-OD upshift (or downshift)

| Checkpoint | Trouble Cause | Countermeasures |
|---|---|---|
| Manual Linkage | Manual linkage out of adjustment | Adjust linkage |
| Throttle Cable | Throttle cable out of adjustment | Adjust throttle cable |
| Valve Body | Valve body faulty | Inspect valve body |
| Solenoid Valve | Solenoid valve faulty | Inspect valve body |
| Transmission | Transmission faulty | Disassemble and inspect transmission |

# Transmission

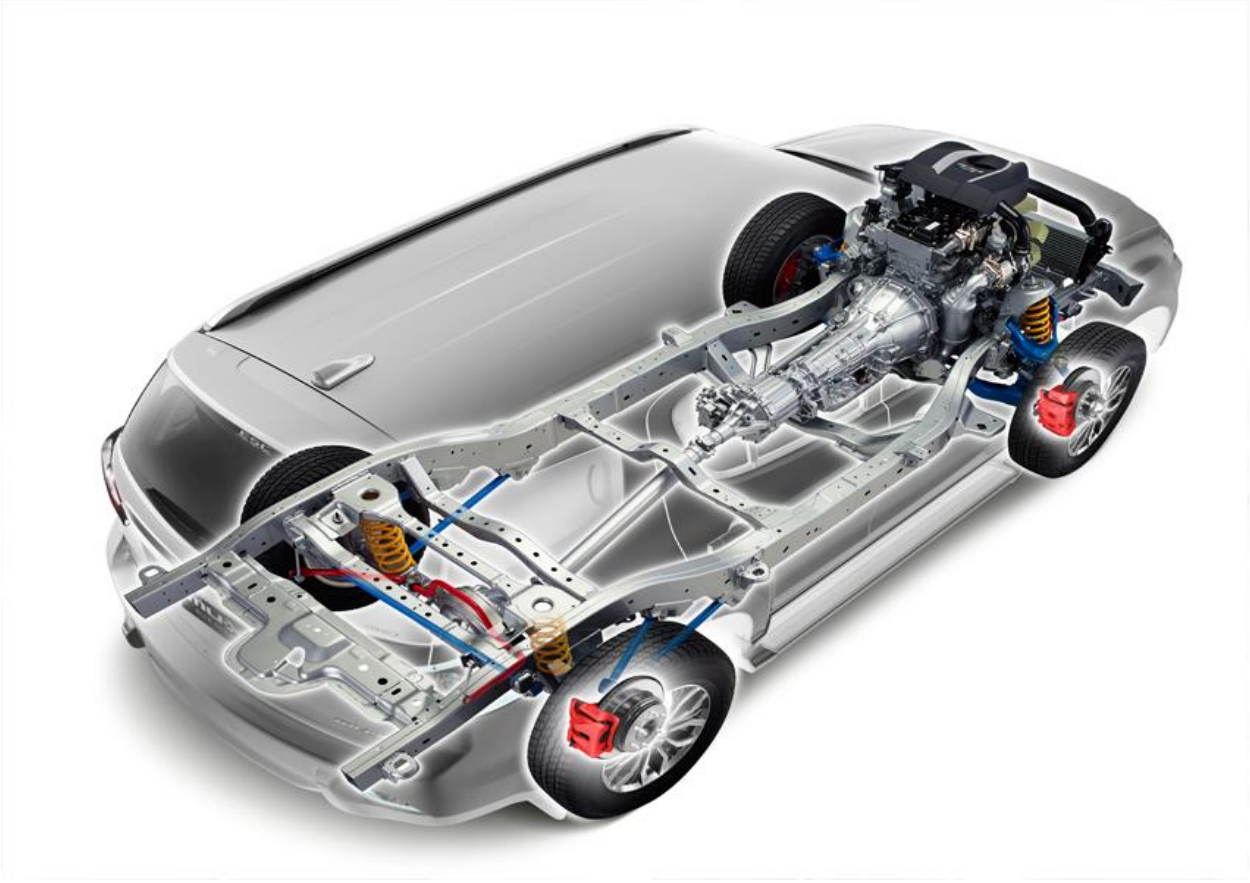
## Automatic Transmission

Basic Troubleshooting and Repair

Problem: Delayed shifting on 1~2, 2~3, or 3~OD (or downshift)

| Checkpoint | Trouble Cause | Countermeasures |
|---|---|---|
| Electronic Control | Manual linkage out of adjustment | Adjust linkage |
| Valve Body | Throttle cable out of adjustment | Adjust throttle cable |
| Solenoid Valve | Valve body faulty | Inspect valve body |

# Differential and Final Drive

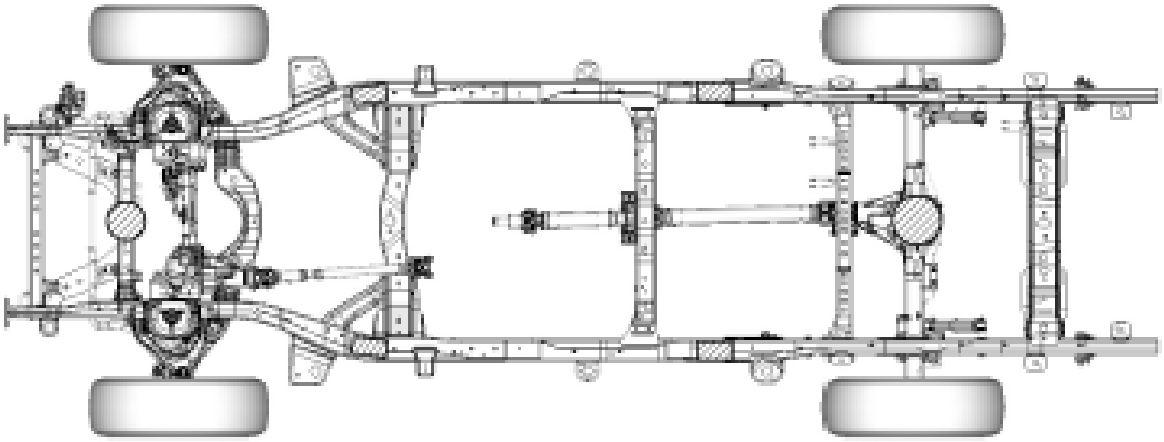


# Differential and Final Drive

## Introduction

As power and torque is being generated by the engine and passes thru the transmission for control, power now must be delivered to the wheels in order to move the vehicle as desired.

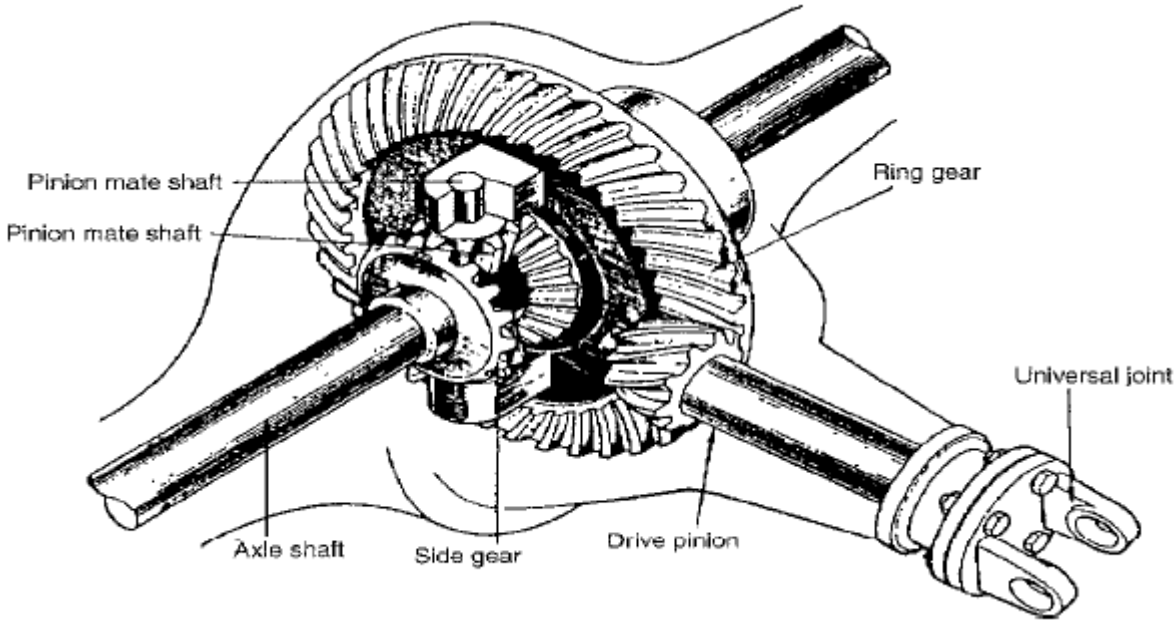
Differential and Final Drive have been designed in order to transmit power from the power train to the wheels at a 90 degree angle in order to propel the vehicle forward or backward while providing the last gear reduction.



# Differential and Final Drive

## Final Drive

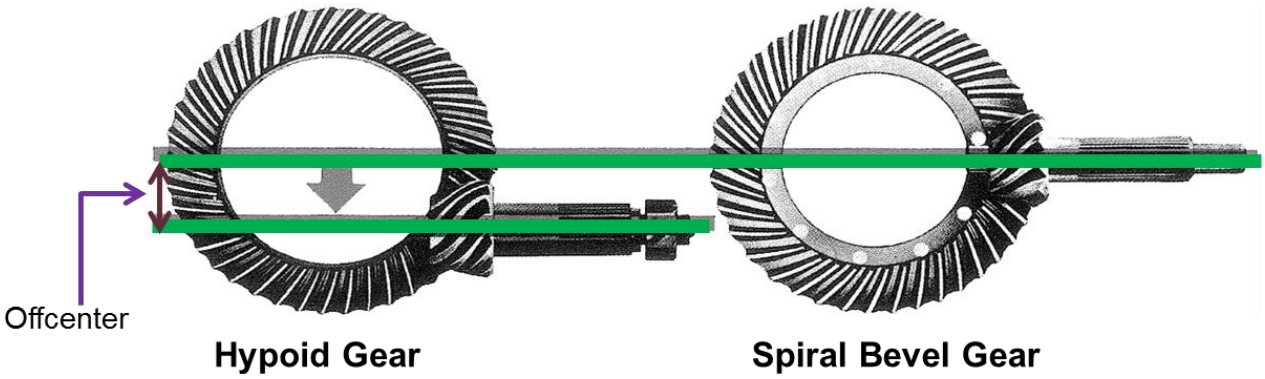
The final drive reduces the engine speed and increases rotation power for increased torque to the drive shaft. The reduction ratio that the final gear creates is determined by a composite of factors which include running resistance, engine output, rotation range, effective tire radius for maximum speed, acceleration performance, climbing power and fuel consumption.




$$\text{Final gear ratio} = \frac{\text{Number of driven ring gear teeth}}{\text{Number of drive pinion teeth}} \quad \left(\text{Example: } \frac{35}{9} = 3.889\right)$$

# Differential and Final Drive

## Types of Final Gear



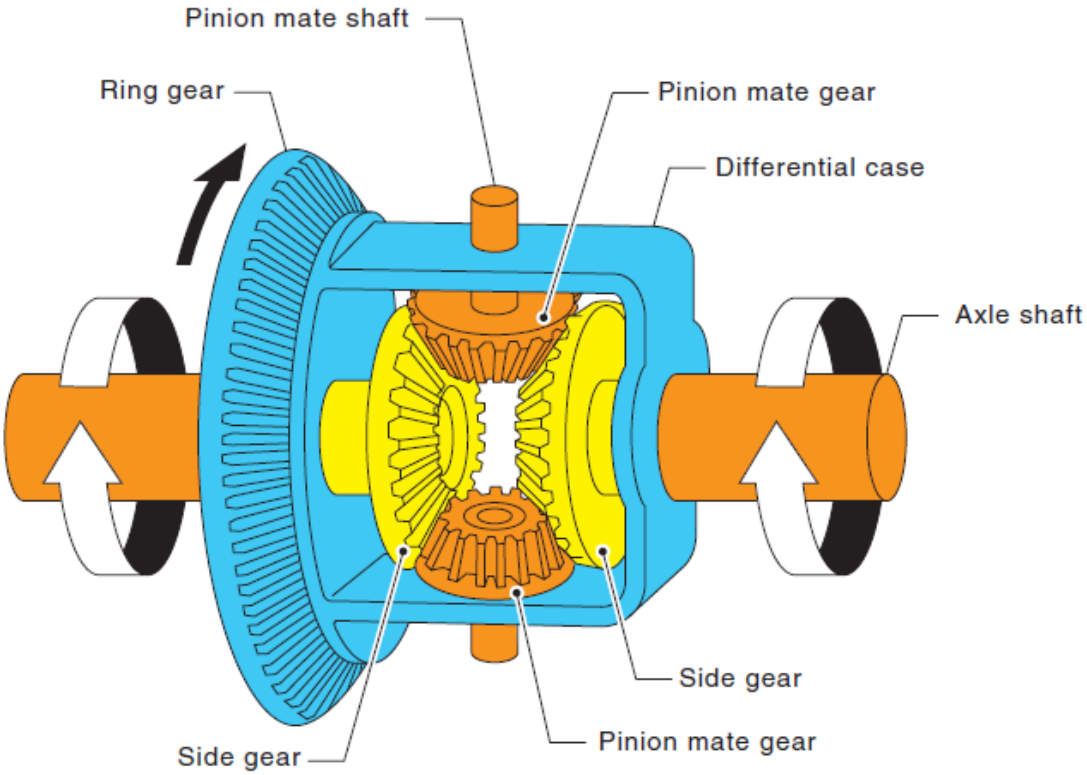

Hypoid Gear – The pinion gear in a hypoid gear set is mounted well below the centerline of the ring gear. This provides a smoother and quiet operation and lowers the center of gravity of the vehicle which provides stability.

Spiral Bevel Gear – It has a curved gear teeth with pinion and ring gear on the same center line. Used extensively on trucks and older automobiles. The design is noisier than hypoid but are easy to manufacture.

# Differential and Final Drive

## Differential

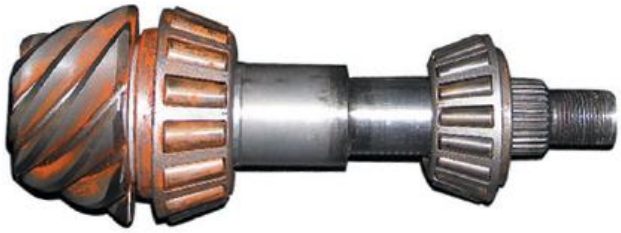
The differential helps torque to be smoothly transferred from the final gear to the wheels. It allows for left and right wheels to rotate at different speeds when turning on a curve or when travelling straight on a rough road.



# Differential and Final Drive

## Parts of a Differential

Drive Pinion – attached to the end of the drive shaft and it rotates the ring gear, reducing the speed of the axle shafts to increase torque.



Ring Gear – It is secured with bolts to the differential case and transmits the power to the axle shafts through the side gears.

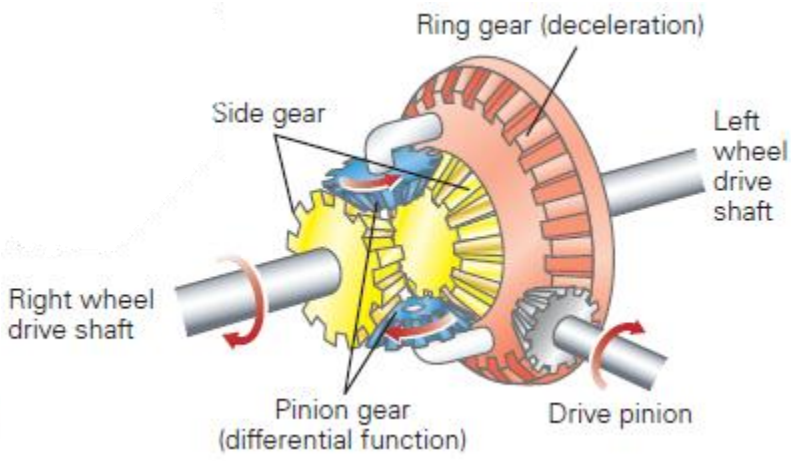
# Differential and Final Drive

## Parts of a Differential

Differential Gear – It permits both wheels to rotate at the same speed during straight driving and at different speeds while turning or driving on a rough road.

Function of Differential Gear

- Deceleration or Torque Increase Function
  - It slows down the rotation speed and increase torque to the drive wheels.
- Differential Function
  - It allows the driving wheels to rotate at different speeds when turning or driving on road irregularities.



# Differential and Final Drive

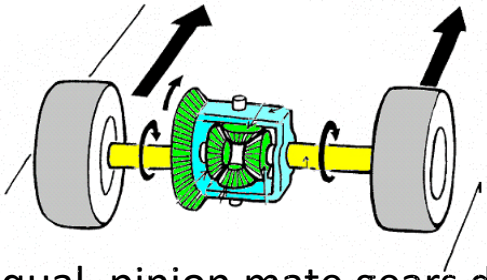
## Parts of a Differential

Differential Carrier – It houses the drive pinion, ring gear and differential gear. The ribs provide strength and rigidity to the carrier and prevents misalignment of gears and application of undue force in bearings and gear teeth due to heavy loads.

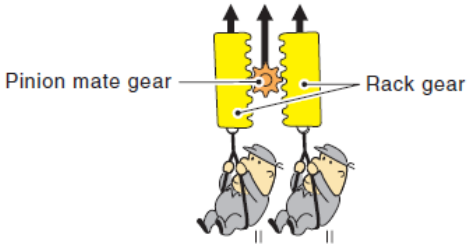
# Differential and Final Drive

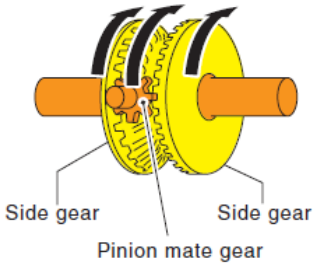
## Operation of Differentials

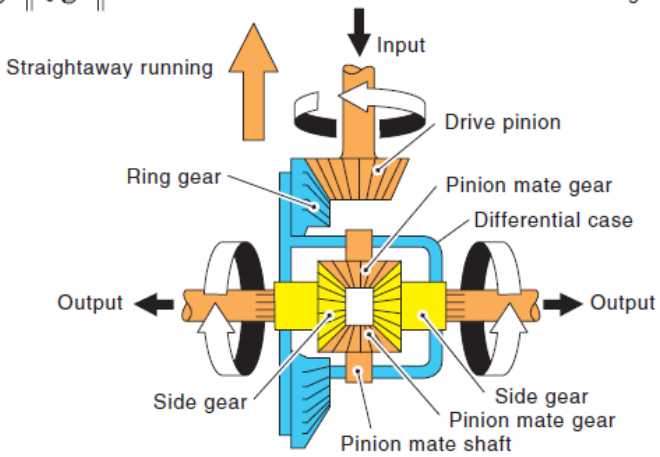
*During Straight Ahead Driving:*



- Speed of both driving wheels is equal, pinion mate gears do not rotate on the pinion mate shaft but revolve as a unit in the differential case.
- Side gears also turn at the same speed
- Rotation of the ring gear is delivered equally to both side gears, as well as the axle shafts.

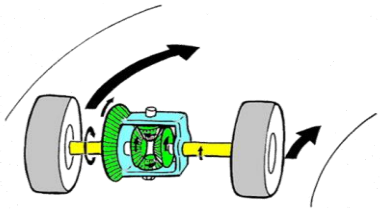


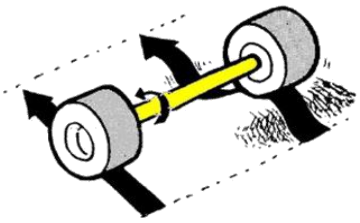
# Differential and Final Drive

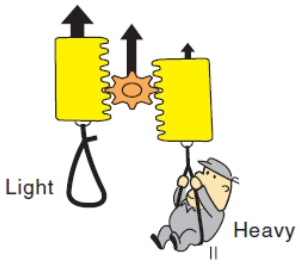
## Operation of Differentials

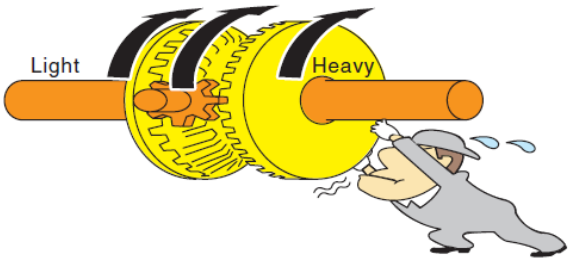


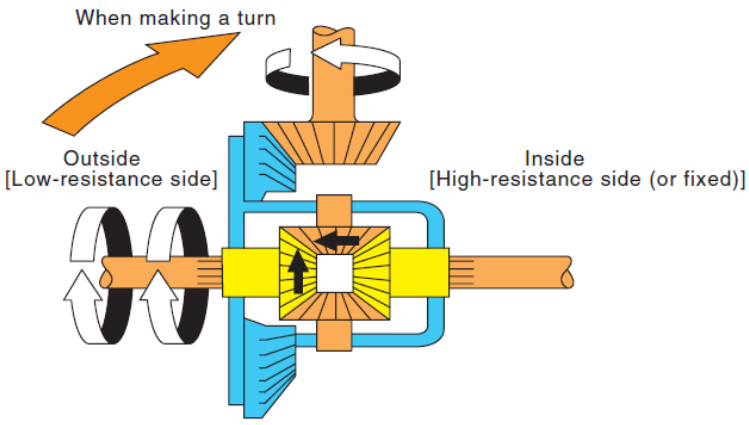
*During Turning or Driving on an Irregular Road Surface with Road Wheels Rotating at Different Speeds:*

- As vehicle turns, inner wheel rotates more slowly than outer wheel.
- Differential Case and pinion mate gears revolve as a unit while the pinion mate gear walk around the side gears, allowing the outer wheel to rotate faster than the inner wheel or during road irregularities.





# Differential and Final Drive

## Limited Slip Differential

Normally for Open/Conventional Differentials, it transfers the torque from the engine to the wheels. It varies the speed of both driving wheels in which the wheel with least resistance rotates faster than the wheel that experiences more resistance. This function of the open differential also applies if a vehicle goes through a road with poor traction and the wheel with less traction tends to rotate more and as a result, the vehicle looses its traction capabilities and will not accelerate forward.

Limited Slip Differential solves this problem by eliminating uneven power distribution which tends to apply more torque to the wheel that has less grip and transfers it to the wheel with a better grip.

# Differential and Final Drive

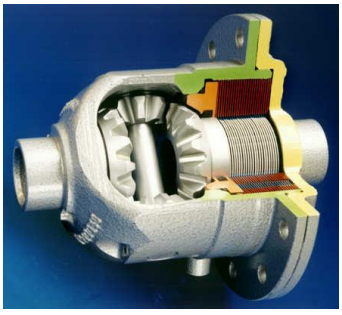
## Limited Slip Differential

Types of Limited Slip Differential

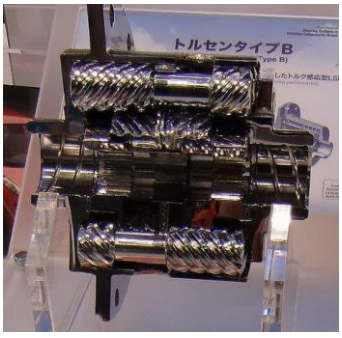
There are different types of limited slip differentials being used in vehicles, some of the examples are:

1.) Multi-Plate Wet Clutch LSD

2.) Viscous Coupling LSD



3.) Torque Sensing (TORSEN) LSD



# Differential and Final Drive

## Limited Slip Differential

Types of Limited Slip Differential

1.) Multi-Plate Wet Clutch LSD

- It has friction discs and plates that are stacked alternately.

- The friction discs engage along with the side gear, while friction plates engage together with the differential case.

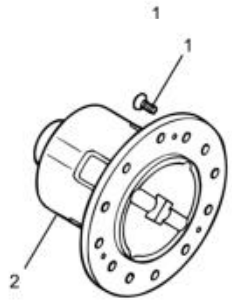
- A spring disc and spring plate are saucer shaped springs which pushes both friction disc and plates to the side gear side.

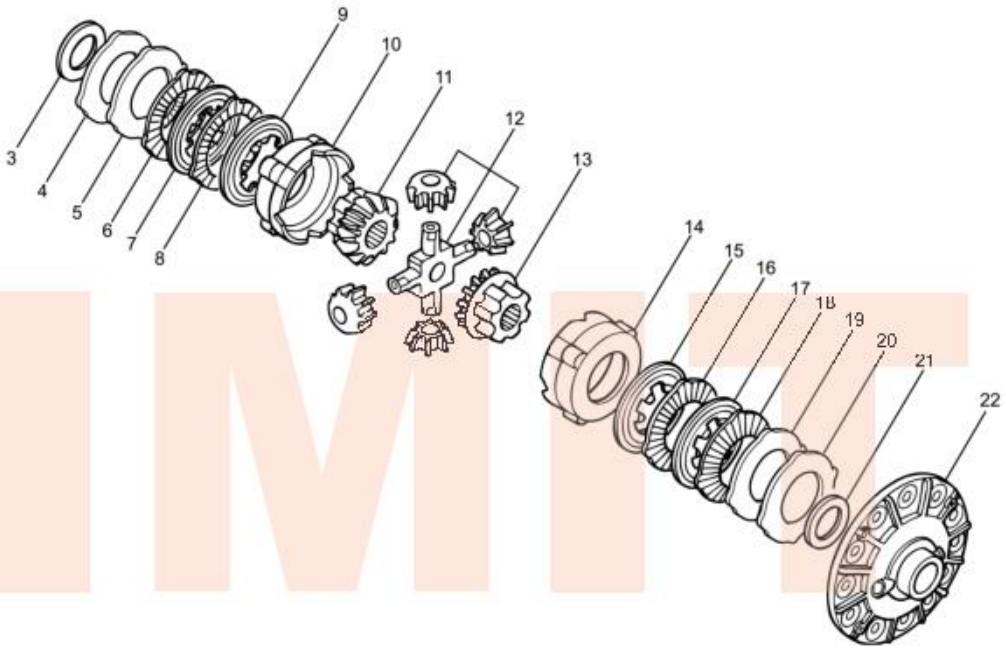
# Differential and Final Drive

## Limited Slip Differential

Types of Limited Slip Differential

1. Screw
2. Drive cage B
3. Thrust washer
4. Spring plate
5. Spring plate
6. Friction plate
7. Friction disc
8. Spring plate
9. Friction disc
10. Pressure ring
11. Side gear
12. Pinion and pinion shaft
13. Side gear
14. Pressure ring
15. Friction disc
16. Friction plate
17. Friction disc
18. Friction plate
19. Spring plate
20. Spring plate
21. Side gear thrust washer
22. Drive cage A



# Differential and Final Drive

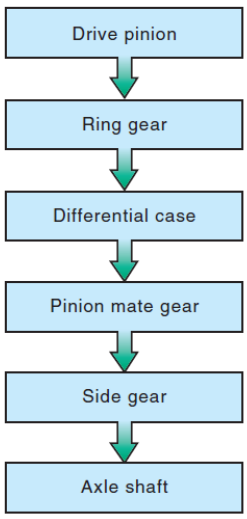
## Limited Slip Differential

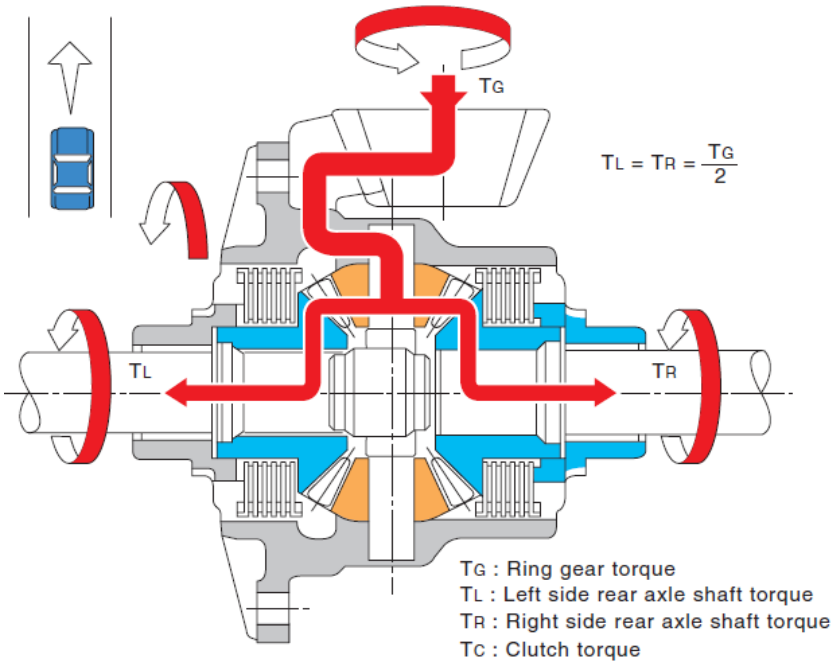
Types of Limited Slip Differential

Operation of Multi-Plate Wet Clutch LSD

*Straight Ahead Driving*

- LSD's at this condition will work similar to conventional differential since equal amount of resistance is applied to both driving wheels.



# Differential and Final Drive

## Limited Slip Differential

Types of Limited Slip Differential

Operation of Multi-Plate Wet Clutch LSD

*One Wheel Rotates Faster than the Other*

- Side gear rotates at different speed than the differential case. Frictional resistance will develop which will control each axle shafts rotational speed and torque.
- Rotational speed of faster wheel will be reduced by frictional plates since it moves faster that the differential case, the slower wheel will now rotate faster due to friction since it moves relatively slower than the differential case.
- The friction between friction discs and plates produces the torque “Tc”, which is added to the wheel that is turning slower, while Tc is taken away from the faster side.

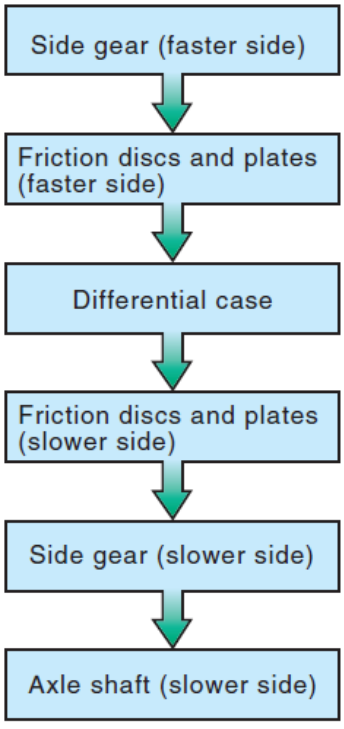
# Differential and Final Drive

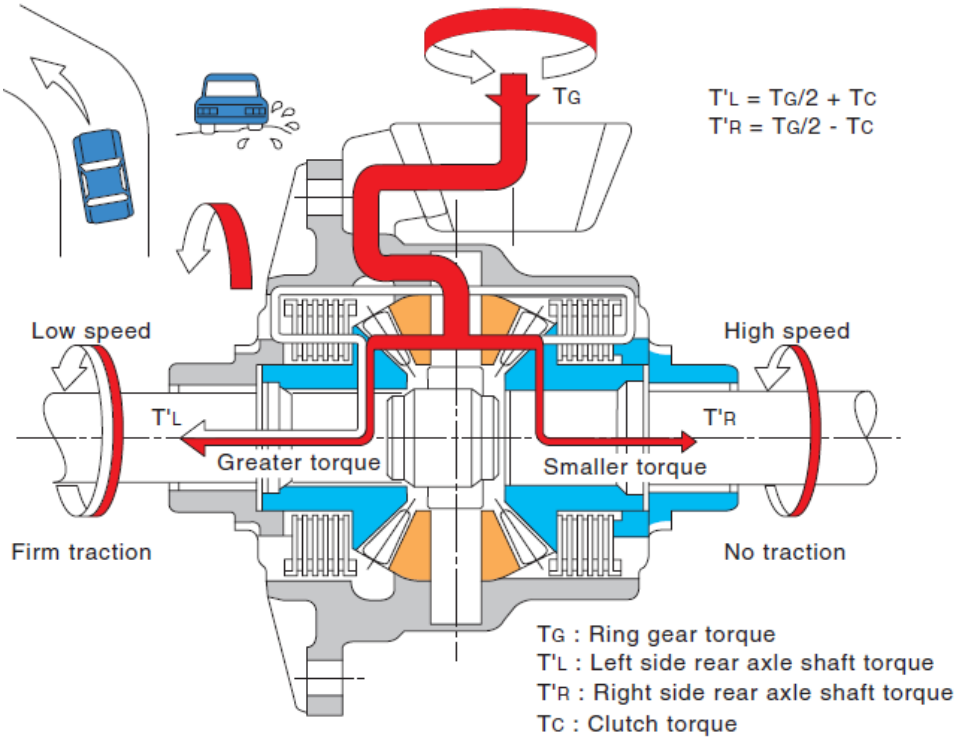
## Limited Slip Differential

Types of Limited Slip Differential

Operation of Multi-Plate Wet Clutch LSD

*One Wheel Rotates Faster than the Other*



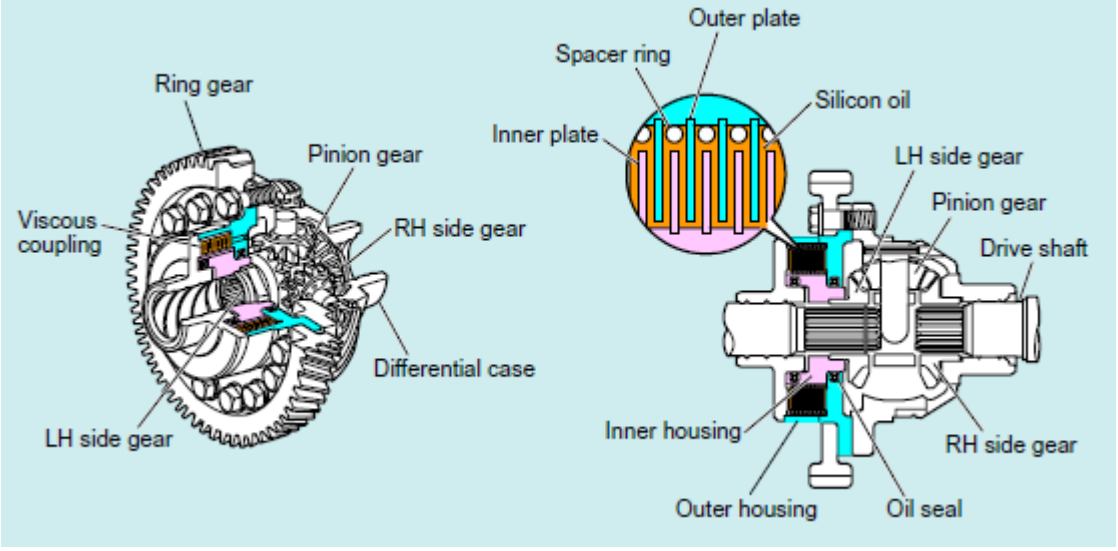
# Differential and Final Drive

## Limited Slip Differential

Types of Limited Slip Differential

2.) Viscous Coupling LSD

- It has fluid coupling or clutch which transmits torque by means of viscous resistance to oil and thus limits differential slip.



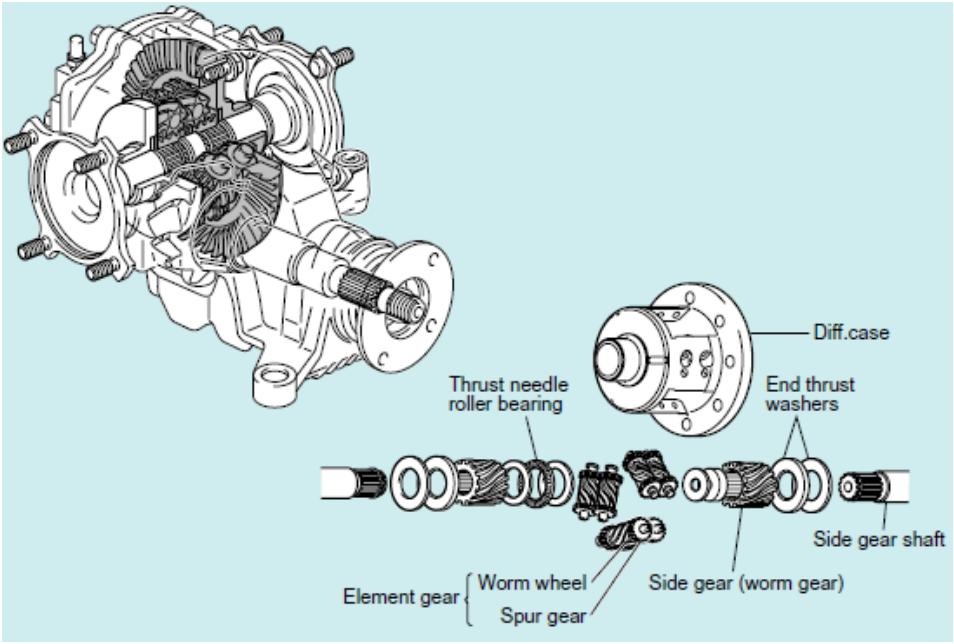
# Differential and Final Drive

## Limited Slip Differential

Types of Limited Slip Differential

3.) Torque Sensing LSD (TORSEN)

- The differential limiting force changes greatly and vary rapidly in accordance with the torque applied to it.
- Differential limiting force is generated by the tooth flank friction between the side gears and worm wheels and the thrust friction between the differential case, thrust washers and side gears.



# Differential and Final Drive

## Fluid Capacities and Replacement Interval LCV

| Model | Differential | Differential Oil | Part No. | QTY | Replacement Interval |
|---|---|---|---|---|---|
| Isuzu D-Max | Front | DELO GL-5 EP (80W-90), (85W-140) | 510411HRK/510412HRK | 2.0L | Every 20,000 Km |
| | Rear | | | 3.0L | |
| Isuzu mu-X | Front | | | 2.0L | |
| | Rear | | | 3.0L | |


Isuzu D-Max


Isuzu mu-X

# Differential and Final Drive

## Fluid Capacities and Replacement Interval CV

### For N-Series

| Model | Differential | Differential Oil | Part No. | QTY | Replacement Interval |
|---|---|---|---|---|---|
| NLR77 | Rear | DELO GL-5 EP (80W-90), (85W-140) | 510411HRK /510412HRK | 2.7L | Every 20,000 Km |
| NLR85 | | | | 3.4L | |
| NMR85 | | | | | |
| NPR85 | | | | | |
| NQR75 | | | | 4.3L | |


# Differential and Final Drive

## Fluid Capacities and Replacement Interval CV

### For F-Series

| Model | Differential | Differential Oil | Part No. | QTY | Replacement Interval |
|---|---|---|---|---|---|
| FRR90 | Rear | DELO GL-5 (80W-90, 85W-40) | 510411H RK/51041 2HRK | 6.5L | Every 20,000 Km |
| FSR34 | | | | | |
| FVR34 | | | | | |
| FVM34 (Tandem Axle) | | | | 14.0L | |


# Differential and Final Drive

## Fluid Capacities and Replacement Interval CV

### For C&E-Series

| Model | Differential | Differential Oil | Part No. | QTY | Replacement Interval |
|---|---|---|---|---|---|
| CYZ52<br>EXR52<br>CYH52<br>EXZ52 | Front | DELO GL-5 (80W-90, 85W-40) | 510411H RK/5104 12HRK | 18.0L | Every 20,000 Km |
| | Rear | | | 12.0L | |

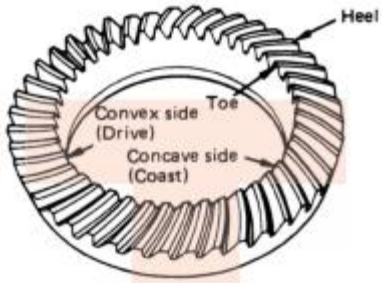
# Differential and Final Drive

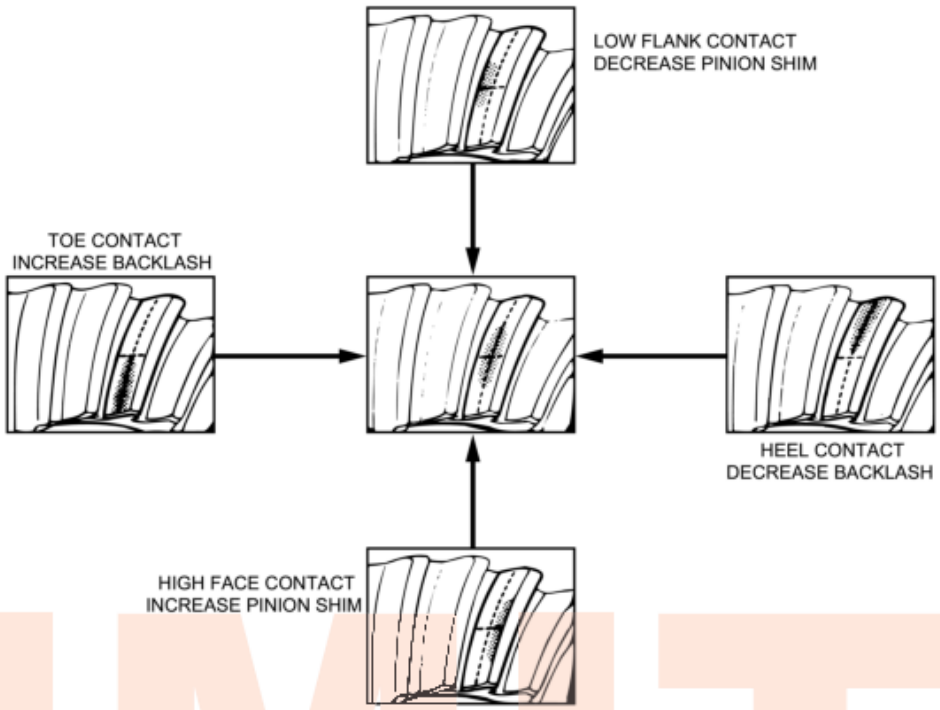
## Limited Slip Differential

Basic Troubleshooting and Repair

Displacement of Tooth Contact Between Drive Pinion and Ring Gear

- Apply red primer to tooth surface 7-8 ring gears.
- Gently turn the drive pinion gear and inspect tooth contact.
- If there is abnormality, adjust as specified



# Differential and Final Drive

## Basic Troubleshooting and Repair

Vibration on Rear Axle

| Cause | Countermeasure |
|---|---|
| Worn Rear Hub Bearing | Replace Hub Bearing |
| Bending of Rear Axle Shaft | Replace Axle Shaft |


# Differential and Final Drive

## Basic Troubleshooting and Repair

Abnormal Sound on Rear Axle

| Cause | Countermeasure |
|---|---|
| Lack of Gear Oil | Refill |
| Wrong Gear Oil/Degradation | Replace |
| Excessive/ Insufficient Backlash | Adjust Back Lash |
| Loose Drive Pinion Bearing | Adjust Drive Pinion Bearing Preload |
| Worn Drive Pinion Bearing | Adjust Differential Side Bearing Preload |
| Worn Differential Side Bearing | Replace |
| Worn/Damaged Drive Pinion/Ring Gear | Replace |
| Excessive Ring Gear Fluctuation | Replace Drive Pinion and Ring Gear |

# Differential and Final Drive

## Basic Troubleshooting and Repair

Abnormal Sound on during Vehicle Coasting

| Cause | Countermeasure |
|---|---|
| Insufficient Backlash of Drive Pinion and Ring Gear | Adjust backlash |
| Damaged Ring Gear | Replace Ring and Pinion Gear |

Intermittent Noise

| Cause | Countermeasure |
|---|---|
| Excessive Play of Axle Shaft Spline | Replace Shaft |
| Ring Gear Distortion | Replace Drive Pinion and Ring Gear |
| Loose Differential Cage Bolt | Tighten |
| Foreign matter on axle case | Remove foreign matter |

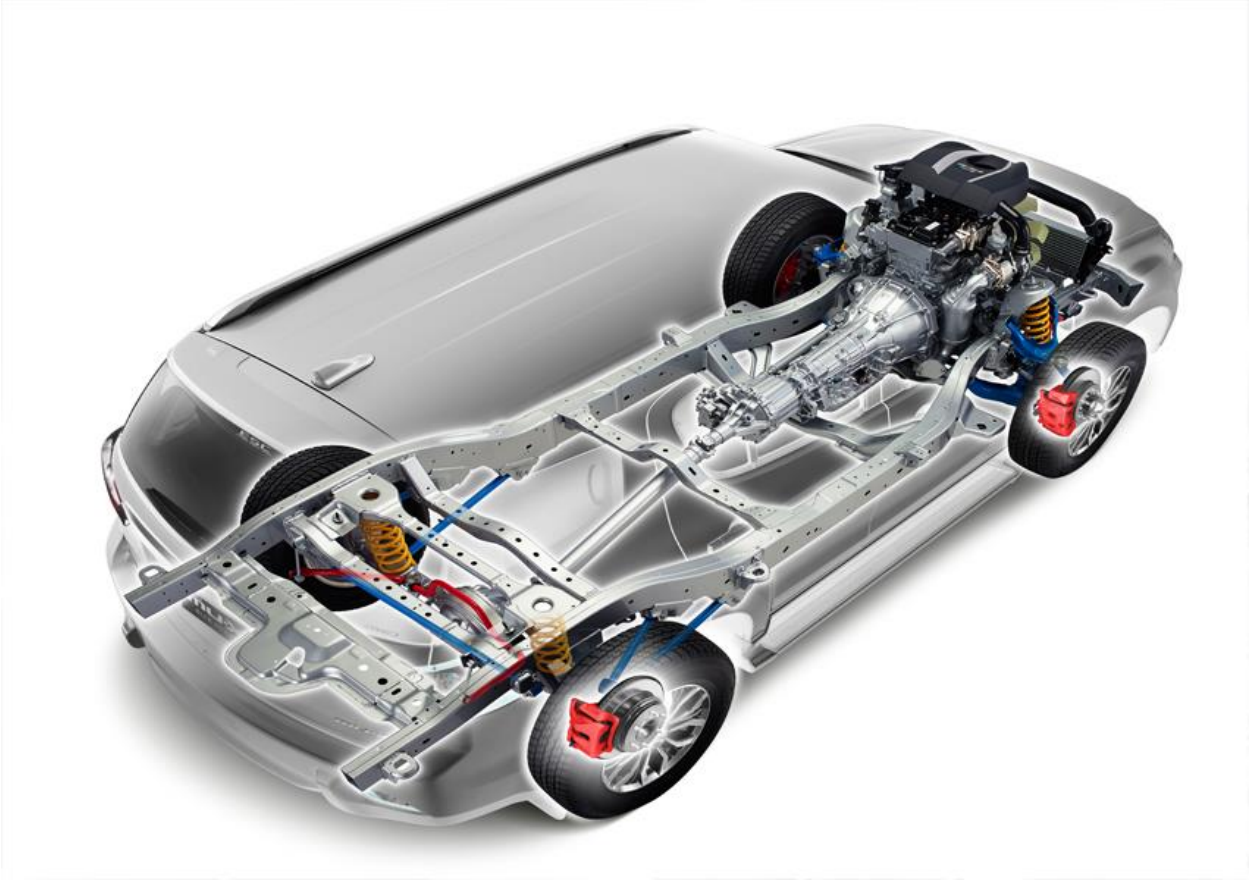
# Differential and Final Drive

## Basic Troubleshooting and Repair

Abnormal Noise when Turning & Constant Abnormal Sound

| Cause | Countermeasure |
|---|---|
| Worn Rear Axle Shaft Spline | Replace Axle Shaft |
| Worn Side Gear | Replace |
| Worn Differential Pinion | Replace |
| Worn Differential Cross Pin | Replace |
| Bending of Rear Axle Shaft | Replace |
| Flat Drive Pinion Gear Tooth Tip | Replace Drive Pinion and Ring Gear |
| Worn Pinion Spline Oil Seal | Replace Drive Pinion and Ring Gear |
| Worn Flat Part of Gear Tooth Tip and Pilot Bearing | Replace Drive Pinion and Ring Gear |
| Flat Part on Drive Pinion | Replace Drive Pinion Bearing |
| Flat Part on Side Bearing Oil Seal | Replace Side Bearing |

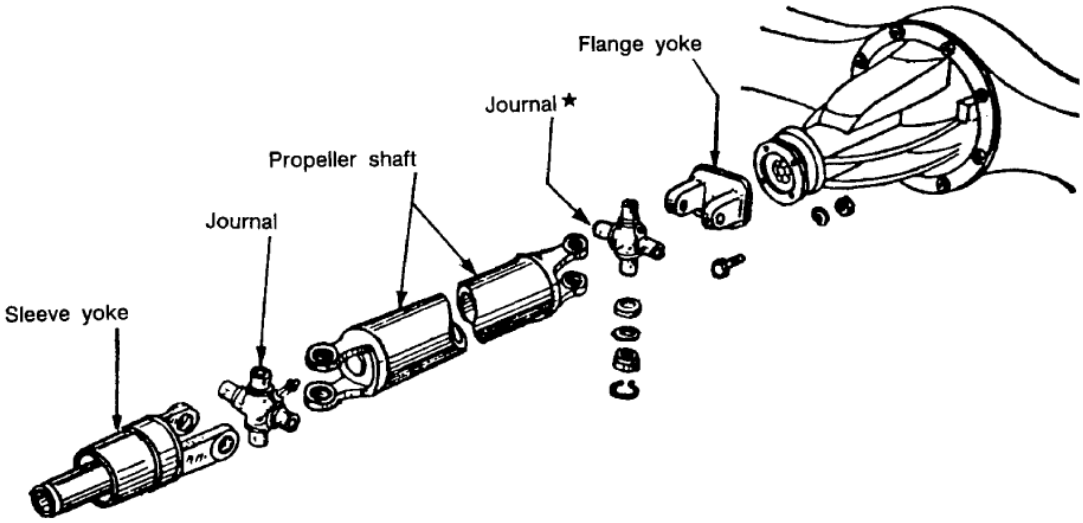
# Propeller Shaft



# Propeller Shaft

## Introduction

The propeller shaft transmits power from the transmission to the differential by using a shaft that will connect the two components. It is installed in such a way that the differential is lower than the transmission or sloped. It has a sleeve yoke and universal joint to accommodate the movement of the rear axle due to varying road conditions.



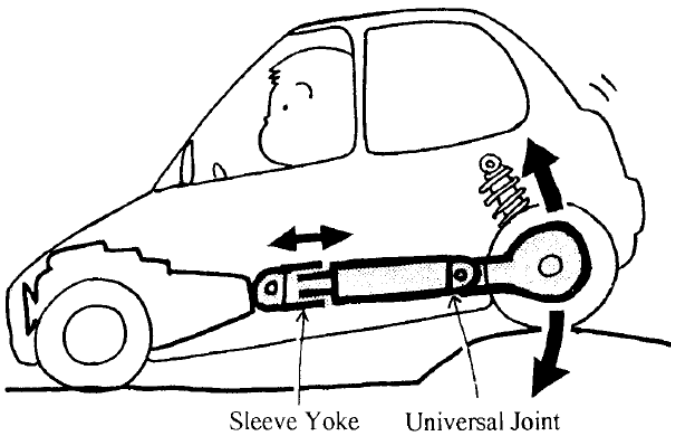
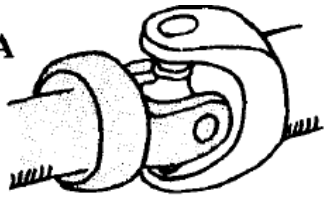
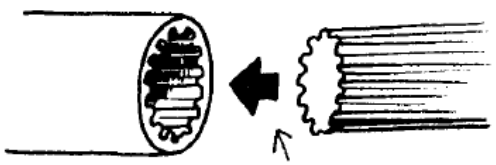




Fig. A



Universal Joint

Fig. B



Sleeve Yoke — Slides in the grooves.

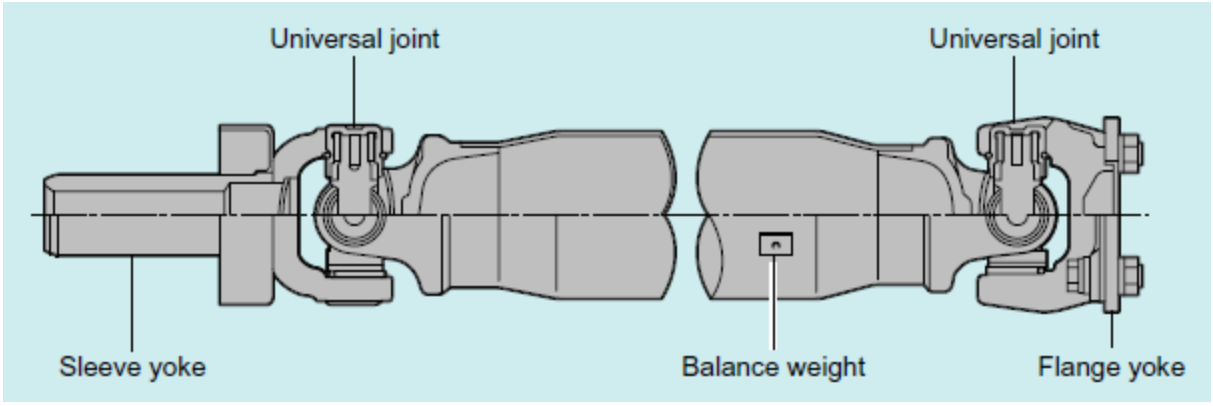
# Propeller Shaft

## Components of Propeller Shaft

Propeller Shaft Tube – it transmits torque from the transmission. Normally a single piece tube with two joints at both ends that form universal joints.

Types of Propeller Shaft:

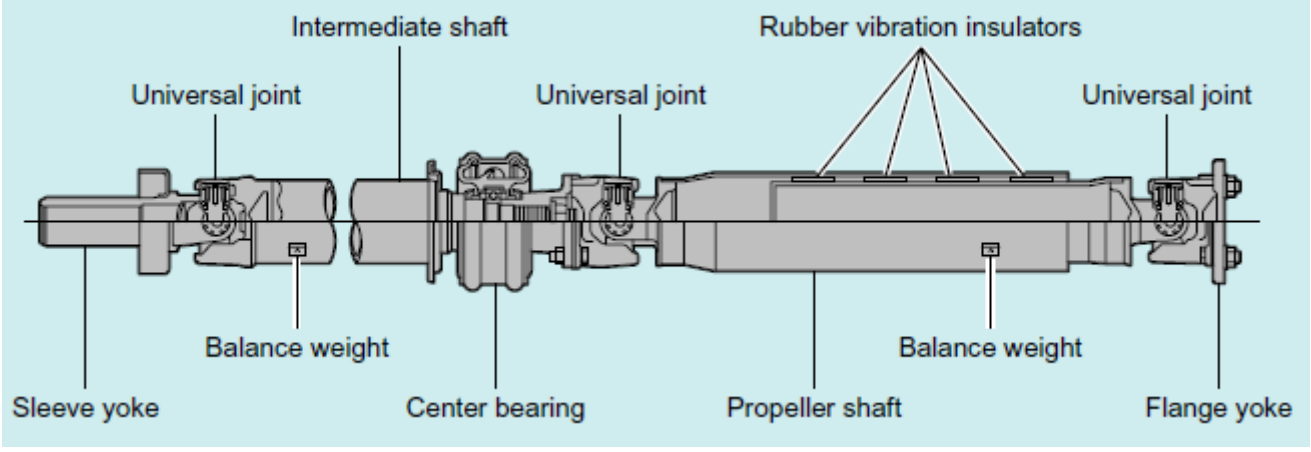
Two Joint Type – overall length of the propeller shaft is relatively great, which causes bending and vibrates more at high speeds.



# Propeller Shaft

## Components of Propeller Shaft

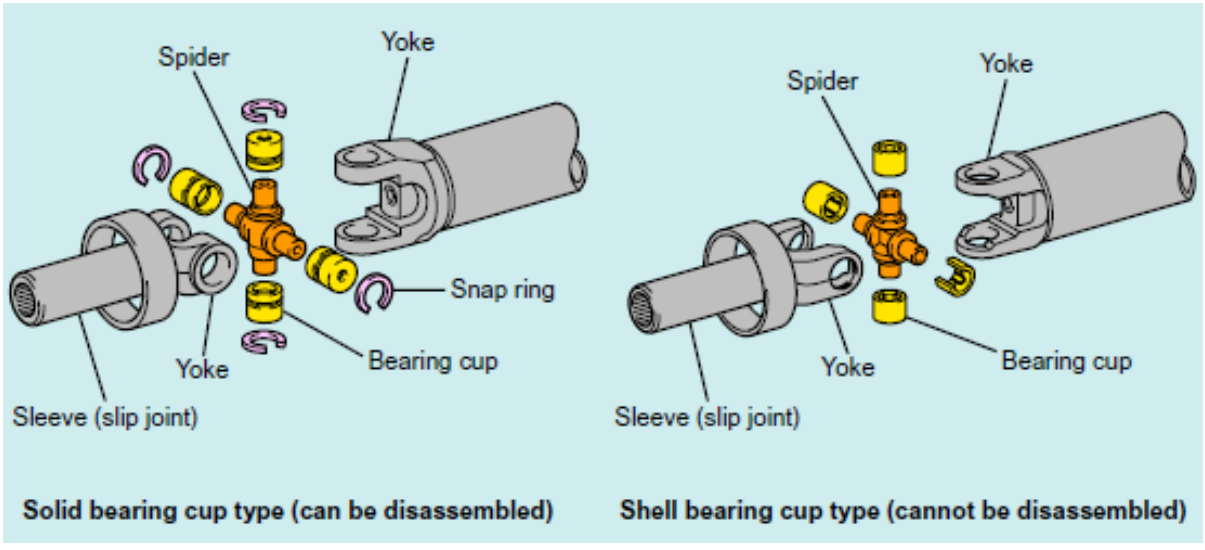
Three Joint Type – It is a two-piece propeller shaft having three joints. It has less vibrations during rotation as the shafts are relatively smaller due to less bending of the shaft even at high speeds.



# Propeller Shaft

## Components of Propeller Shaft

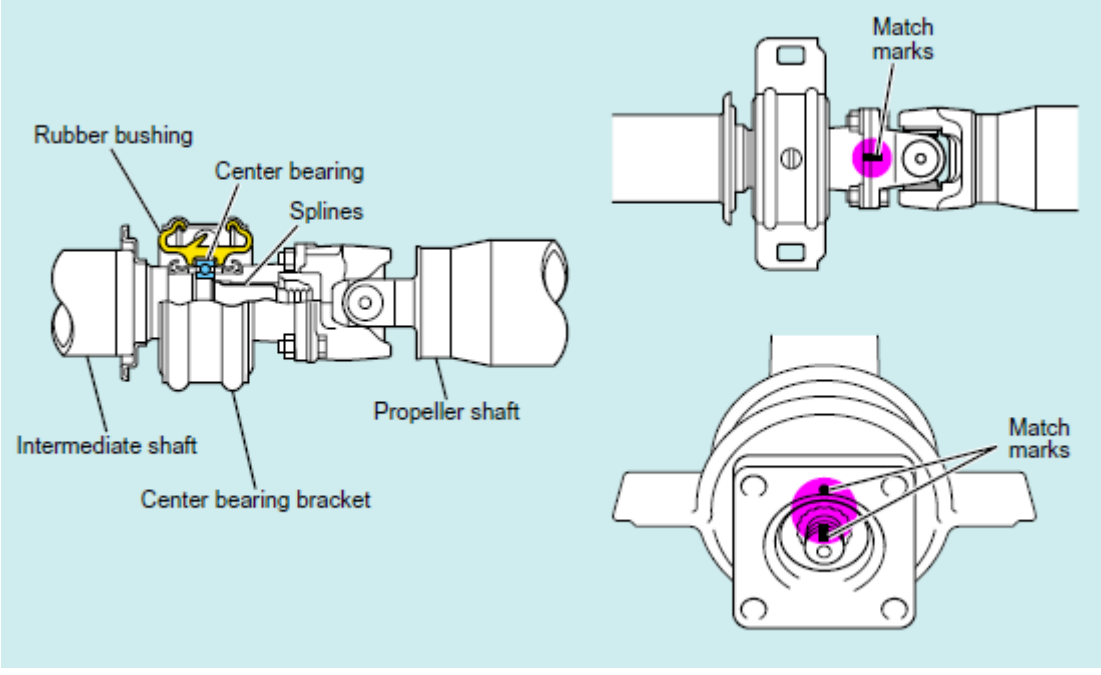
Universal Joint – It absorbs the angular changes brought about by changes in relative positions of the differential in relation to the transmission and provides smooth transmission of power from the transmission to the differential.



# Propeller Shaft

## Components of Propeller Shaft

Center Bearing – It supports the two parts of the propeller shaft in the middle and is installed via a flange to the splines located at the end of the intermediate shaft. It has rubber bushings which acts as cover for the bearing, supporting the propeller shafts and also absorbs the vibrations of the shaft isolating the body of the vehicle.

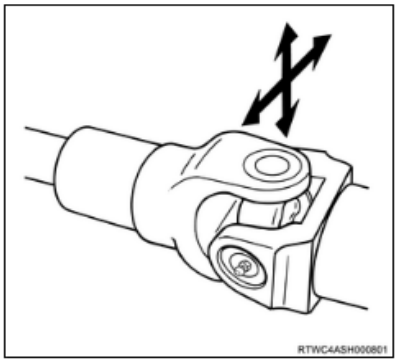


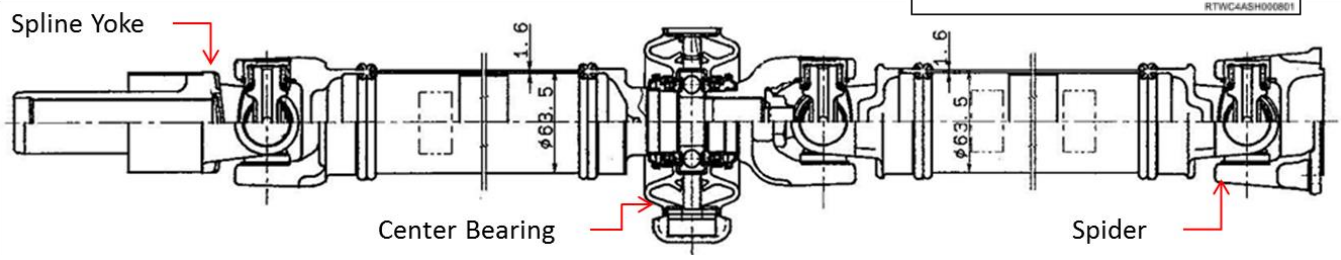
# Propeller Shaft

## Propeller Shaft Inspection

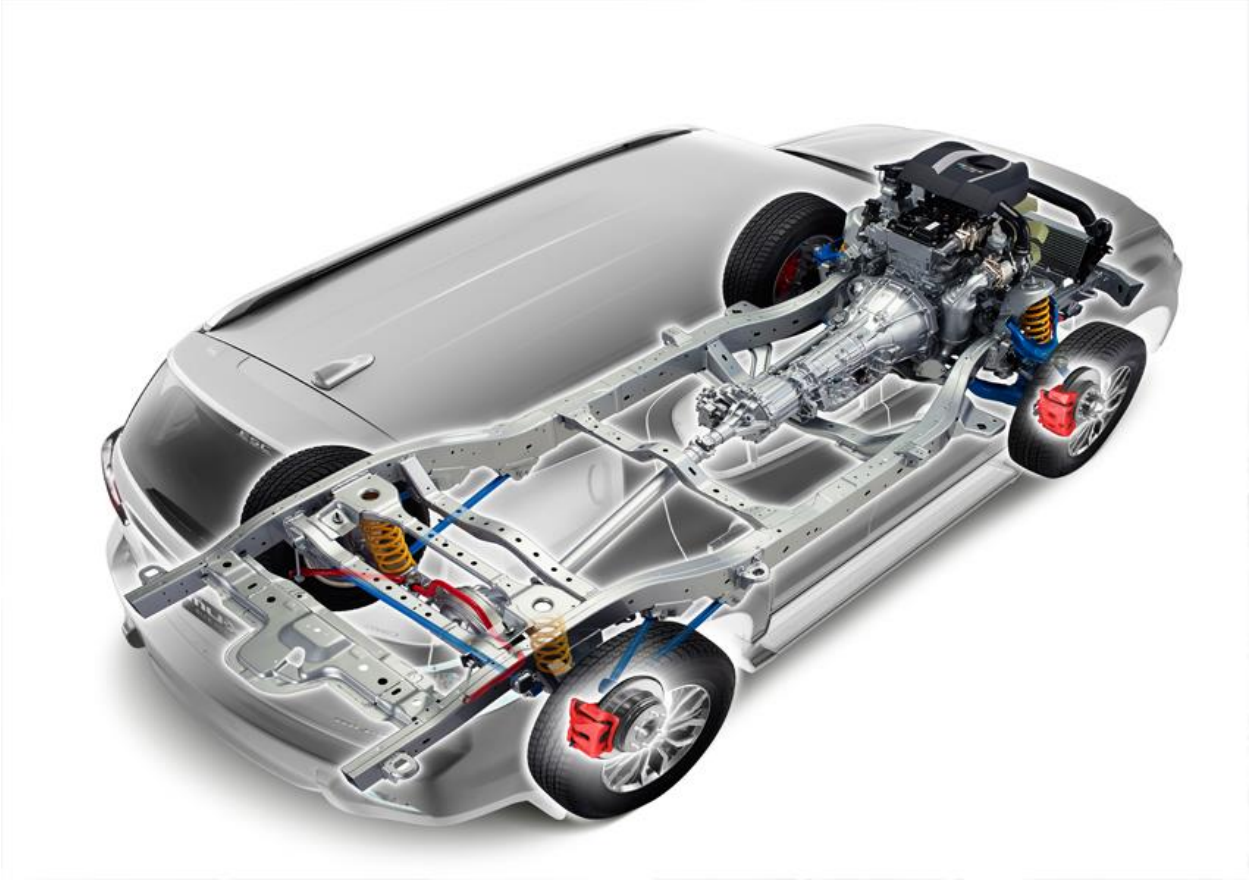
a. Inspect the propeller shaft.
   - Inspect the following parts for worn, damage or other abnormal conditions:
     - Spider, needle roller bearing, yoke, flange, center bearing, bracket

b. Inspect the journal assembly
   - Inspect the play of the journal assy. at the following methods:
     - Check the bearings for wear or damage.
     - Move the yoke back and forth on the spider and shaft axis to inspect the play of the axial and radial direction of the journal assy.





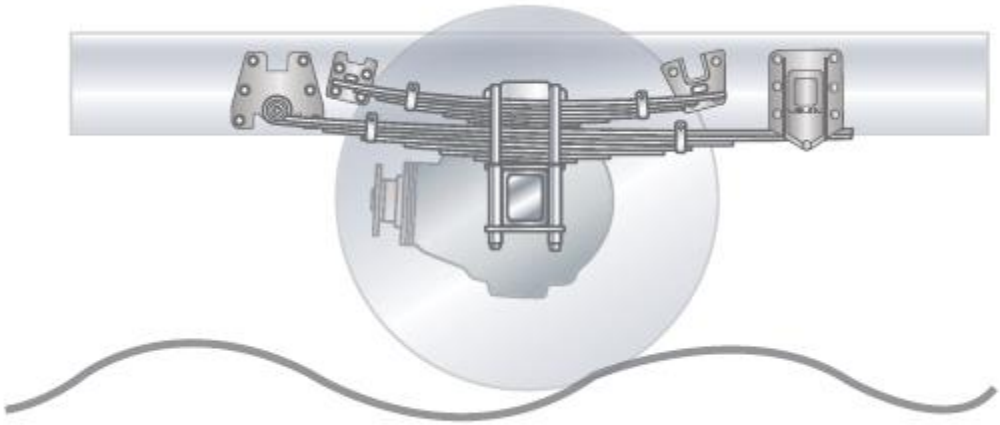
# Suspension System



# Suspension

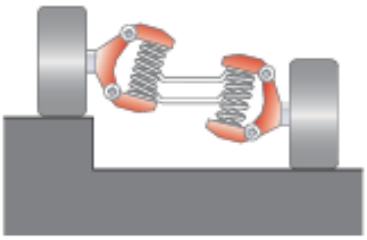
## Introduction

Suspension system supports the load of the vehicle as well as enhancing riding comfort and maintains its stability over uneven and bumpy terrain.



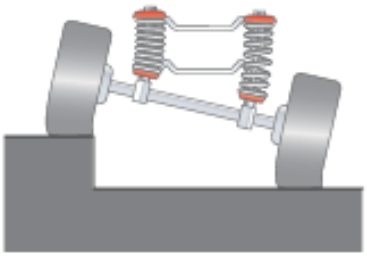
Types of Suspension System

**Independent suspension (independent suspension system)**



The system which supports each wheel with a separate suspension. Non-suspended/unsprung weight is low, and the vehicle is comfortable to ride in. In addition, it is excellent in small turns and is mainstream in the front suspension system of light trucks.

**Rigid suspension (rigid axle suspension)**



This system supports the wheel shaft's right and left axle pair. The mechanism is simple, with excellent durability, and is used widely in trucking. Since the shock of the road surface received by one wheel is transmitted across to the opposite wheel, the ride comfort is inferior compared to the independent suspension system.

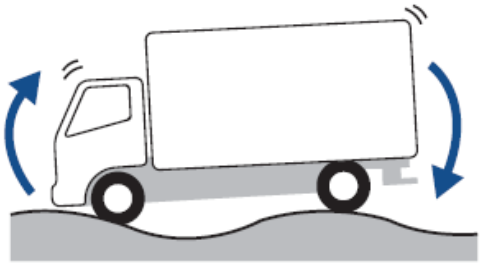
# Suspension

## Types of Vibrations

When the vehicle is running, it may experience the following conditions due to vehicle inertia and road surface unevenness.

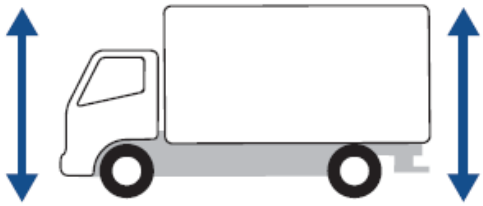
### Pitching

The vehicle moves up and down, with shifting opposite motion, like a seesaw.



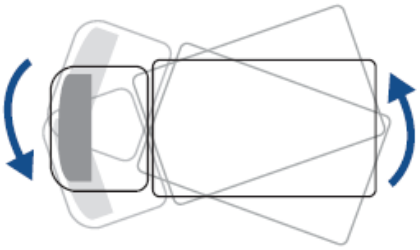
### Bouncing

The whole vehicle moves up/down and back/forth in the same phase.



### Yawing

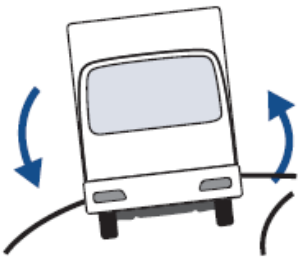
The front end of a vehicle swerves right and left.



Yawing occurs by front wheel alignment, play of the steering, etc., in many cases.

### Rolling

The vehicle sways from side to side, for example from cornering.



**Roll rate**

The roll rate is the degree of tilt when the vehicle is turning. The smaller the roll rate, the greater the driving stability. However, the ride comfort becomes poor if the suspension is hard, and it is necessary to strike a good balance between the ride comfort and driving stability.

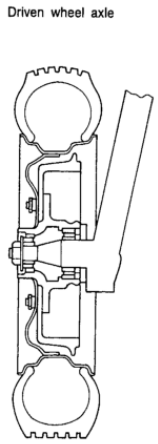
# Suspension

## Axles

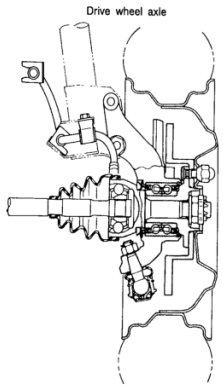
Axles support the weight of the vehicle and it varies in design according to the type of suspension and power train. For front axles, it transmits directional control via the steering system and driving force for rear axles. It also supports the weight of the vehicle as suspension systems are also mounted to it.

Type of Axles:

1.) Driven Wheel Axle – it simply holds up the weight of the body and the load it carries.




2.) Drive Wheel Axle - Aside from holding the weight of the vehicle, it also transmits torque from the engine to propel the vehicle.



# Suspension

## Axles

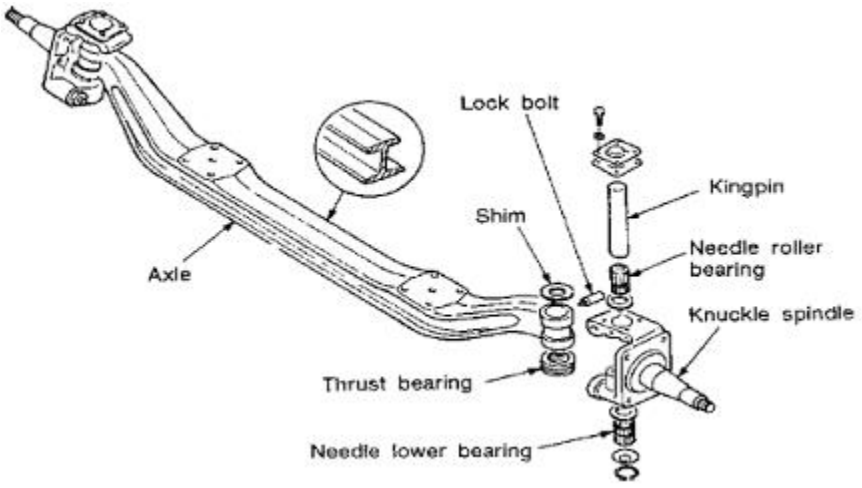
*Front Axle*

It supports the front wheel load and is used to control the driving direction. For four-wheel drive vehicles, it also provides driving torque once torque is transmitted to it from transmission via a transfer.

Types of Front Axles:

*Rigid Axle (Driven Wheel Type)*

It connects the left and right wheels on a single axle. It is strong and large in structure usually used for commercial vehicles.



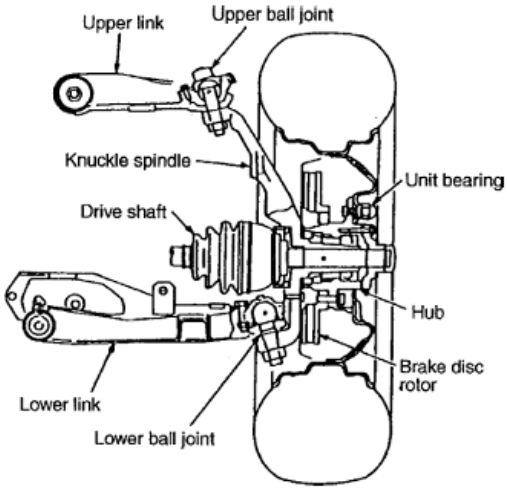
# Suspension

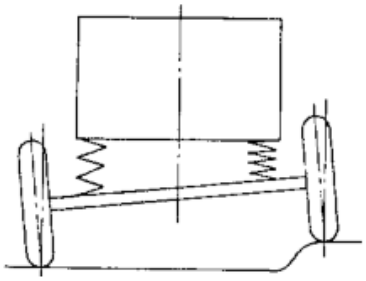
## Axles

Types of Front Axles:

*Independent Suspension (Drive Wheel Type)*

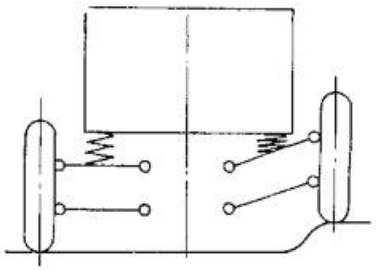
It has same purpose as the rigid axle, however it allows each wheel to move independently compared to rigid axles.



TSU003

**RIGID AXLE TYPE SUSPENSION WITH ONE WHEEL RAISED**
**(The angle of both wheels is affected)**



TSU004

**INDEPENDENT SUSPENSION WITH ONE WHEEL RAISED**
**(The angle of the wheels to the ground has not changed)**

# Suspension

## Axles

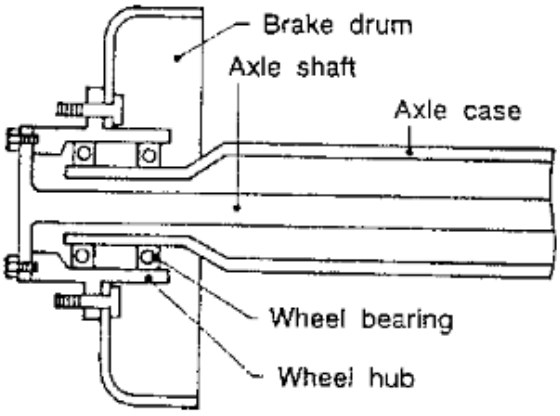
*Rear Axle*

It supports the weight of the frame similar to front axles and also provides traction to propel the vehicle (for rear wheel drive vehicles).

Types of Rear Axles:

*Full Floating Rear Axle*

Wheel hub is connected by two bearings on the end of the free floating axle case. The entire weight of the vehicle is supported by the axle case and torque is transmitted by the axle shaft only.



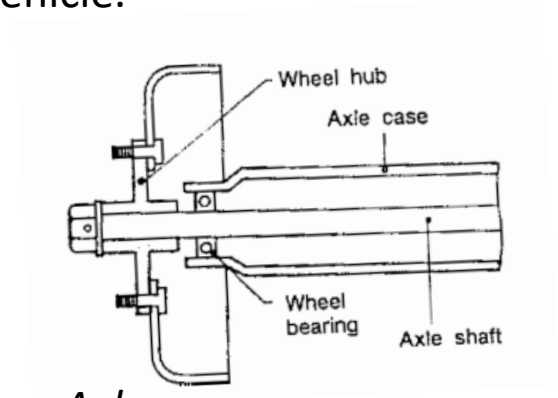
# Suspension

## Axles

Types of Rear Axles:

*Semi Floating Rear Axle*

There is a bearing between rear axle shaft and axle case. Rear axle shaft not only transmits torque but also supports the weight of the vehicle.




*Independent Rear Axle*

It does not require an axle case as the rear wheels are independently sprung.

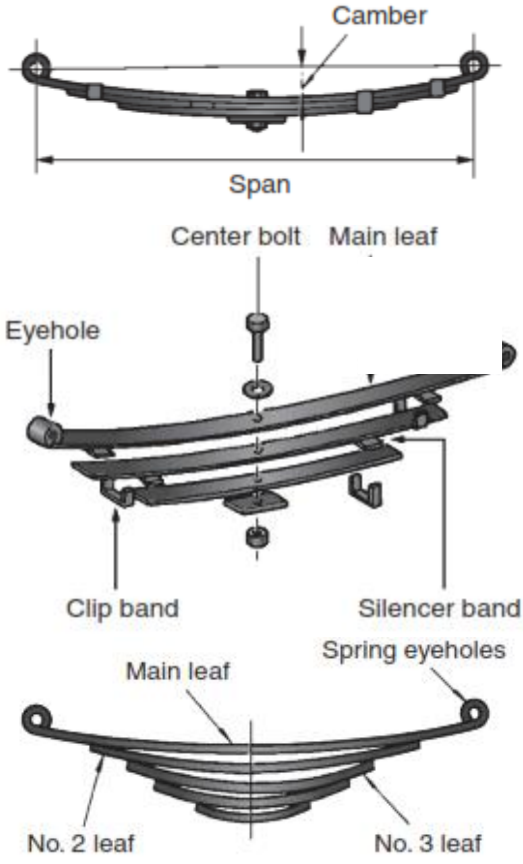
# Suspension

## Suspension Components

Springs – It softens the shock experienced by the vehicle by absorbing the vibrations from the road surface.

Types of Springs:

Leaf Spring – Tiered up and cambered spring steels in the shape of leaves set-up with bolts or clips that can support heavy load.

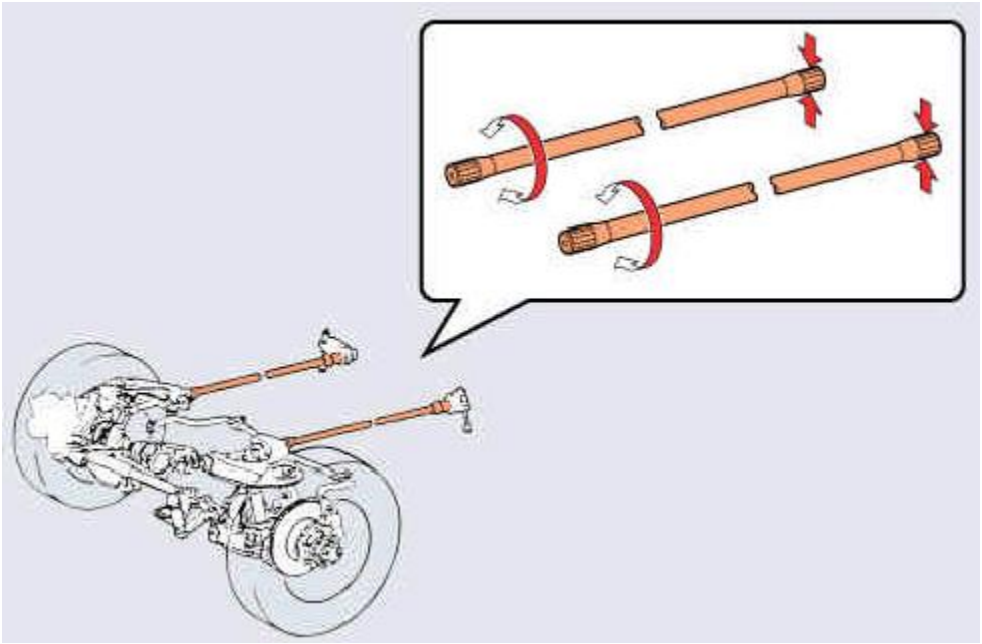


# Suspension

## Suspension Components

Torsion Bar – A steel bar that functions as a spring, and is efficient with a light and simple structure, though cannot make long strokes.





# Suspension

## Suspension Components

Coil Spring – Made out of Spring Steel, it is wound in a spiral configuration with the following characteristics:

1. Small spring constant can be achieved.
2. Weight is reduced and compact in structure.
3. Weight under the spring and riding comfort is improved.

Spring diameter and pitch can be configured so that it can be soft on light load and hard for a heavy load.

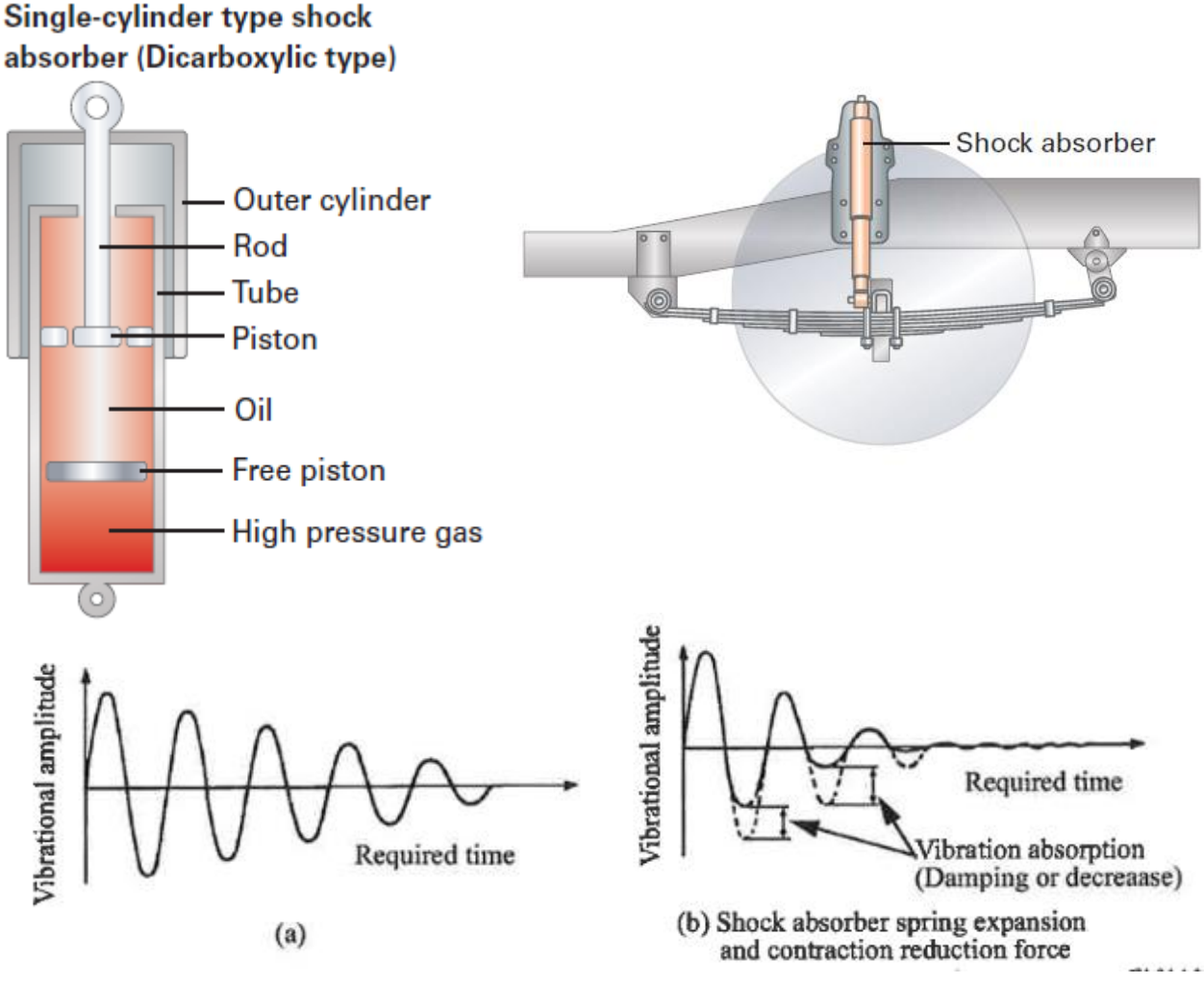
**Variable Rate Coil Spring**


**Constant Rate Coil Spring**

# Suspension

## Suspension Components

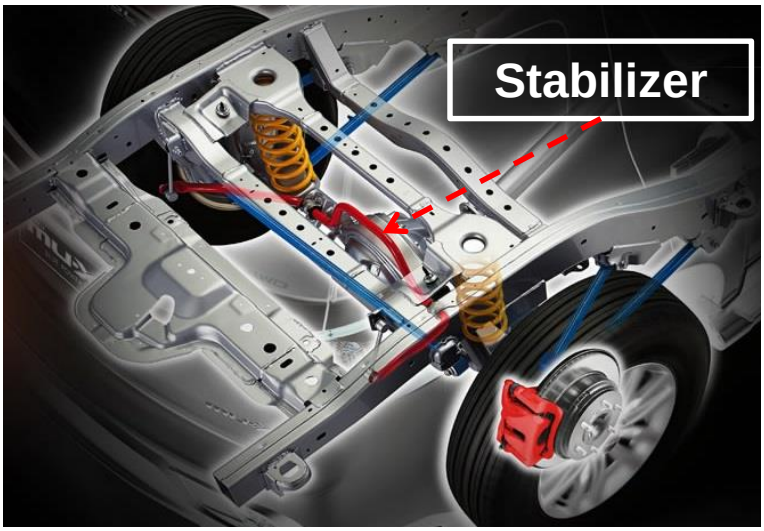
Shock Absorber – It restrains the movement of the springs by the resistance of the oil that flows through a path in the piston. They also absorb the vibrations of the vehicle body and give a good ride.

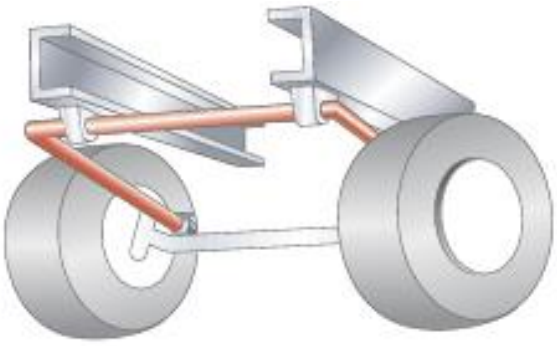


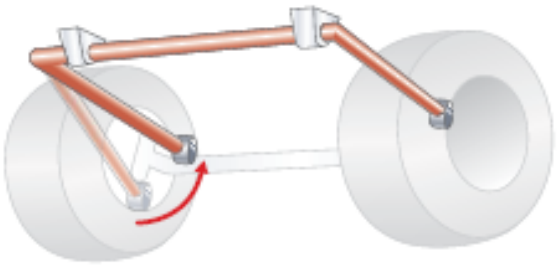
# Suspension

## Suspension Components

Stabilizer – It is a device that enhances the vehicle's ability to drive on curves and prevent rolling. Typically made of a steel rod and is used to keep the vehicle level by repulsing or countering the opposing forces of twisting and turning.



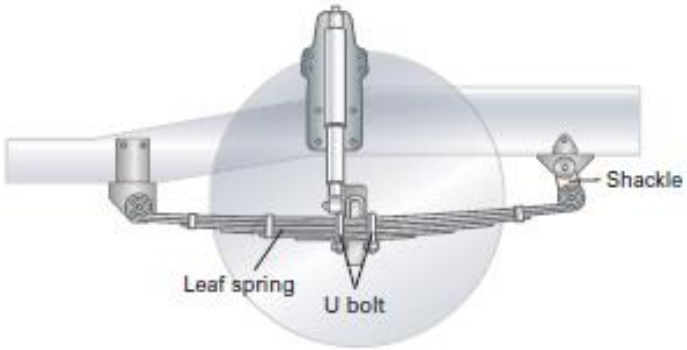


Repulsive or counter force that acts on the twist

# Suspension

## Front Suspension

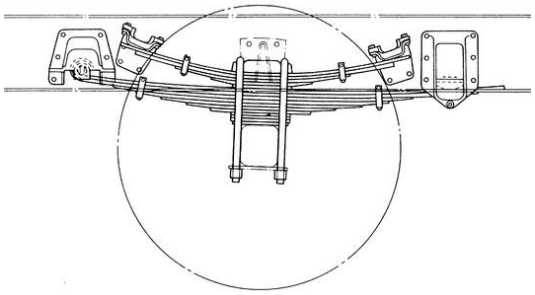
Rigid Leaf Spring Suspension



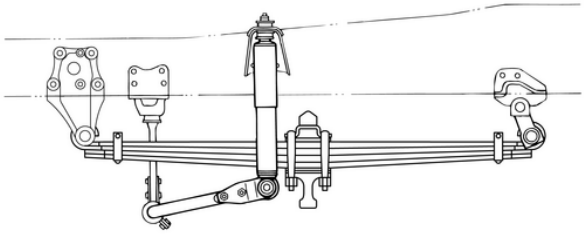

A type of front suspension which uses overlapping leaf springs. It is simple in structure and has strength to withstand heavy loads.

Types of Leaf Spring Suspension

Multi-Leaf Spring (MLS)



Taper Leaf Spring (TLS)

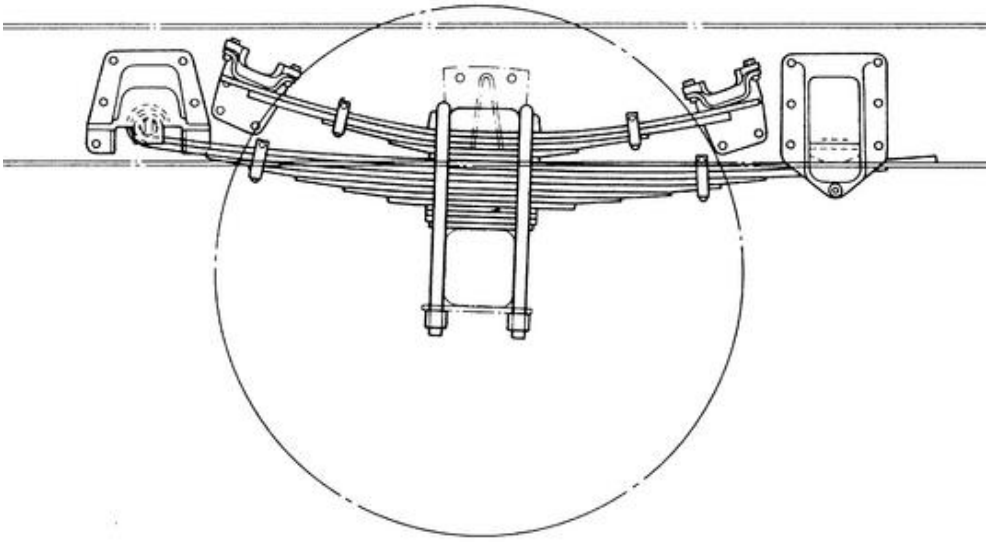


# Suspension

## Front Suspension

Types of Leaf Spring Suspensions

Multi-Leaf Spring (MLS) – usually in a semi-elliptical shape composed of flat plates or leaves with constant thickness. The length of leaves gradually decreases from the top leaf or master leaf to the bottom leaf in which each leaf is designed to carry a proportionate amount of load and stress.

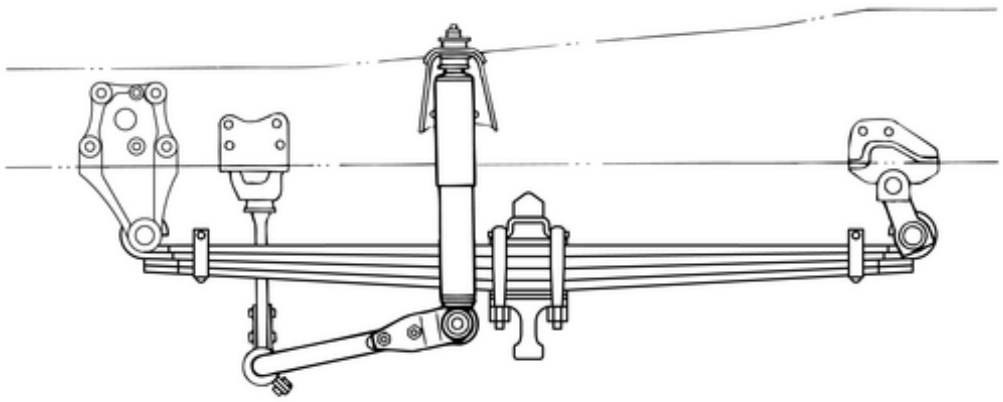


# Suspension

## Front Suspension

Types of Leaf Spring Suspensions

Taper Leaf Spring (TLS) – It has leaves with varying thickness but having constant length. It reduces spring stiffness for improved ride quality and reduced interleaf friction.

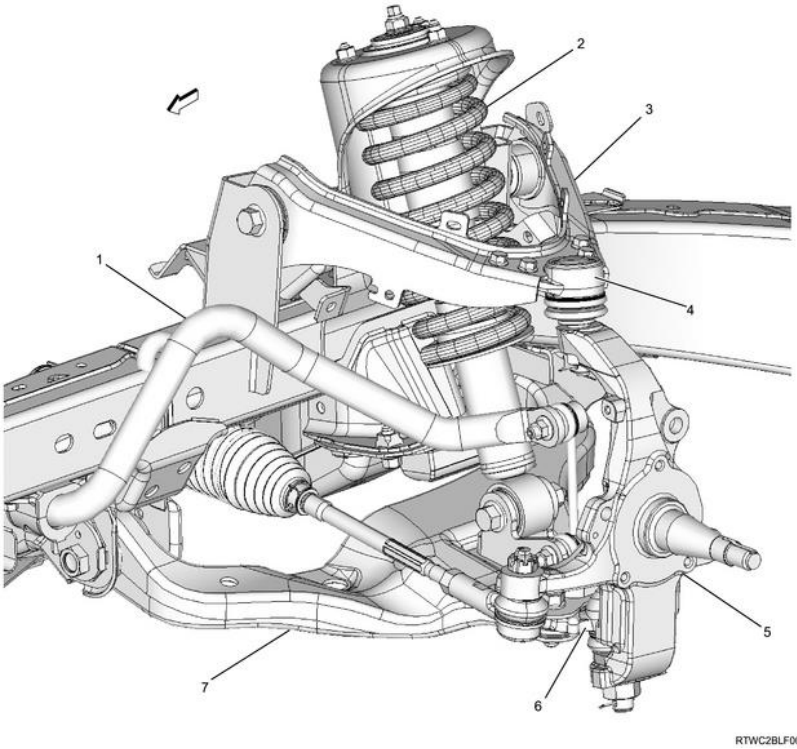


# Suspension

## Front Suspension

Double Wishbone Front Suspension

An independent suspension which uses to wishbone shaped links/arms to locate the wheel. Has two mounting points, one on the chassis and the other on the knuckle. With this design, wheel alignment parameters are controlled including camber, caster, toe, roll center etc.

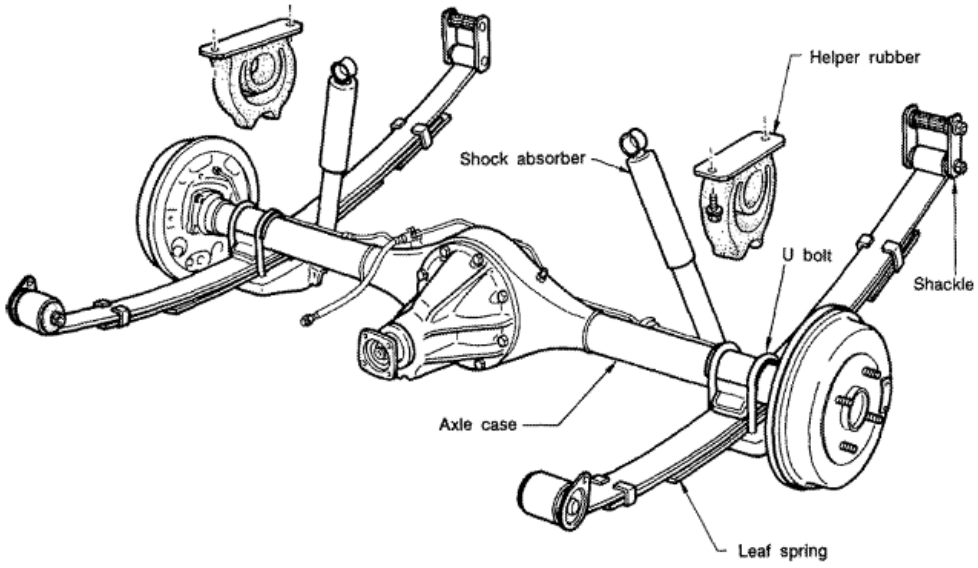


# Suspension

## Rear Suspension

Rigid Leaf Spring Rear Suspension

Installed parallel to the vehicle, it absorbs road shock and holds the axle in position. All of the wheel traction, brake force and lateral force from turning is transmitted through the spring to the body.

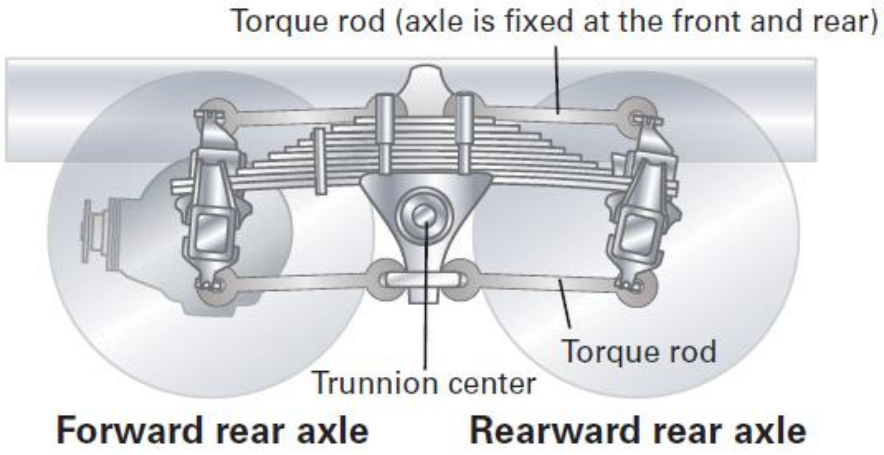


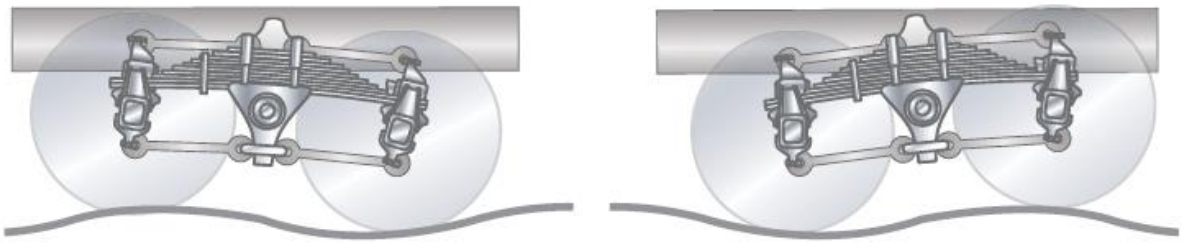
# Suspension

## Rear Suspension

Trunnion Type Rear Leaf Spring Suspension

The fulcrum, called a trunnion center, is placed between the front and back of the rear axle and supports it with a leaf spring, allowing forward and rearward rear axle to move up and down in a seesaw like manner to increase road holding performance.



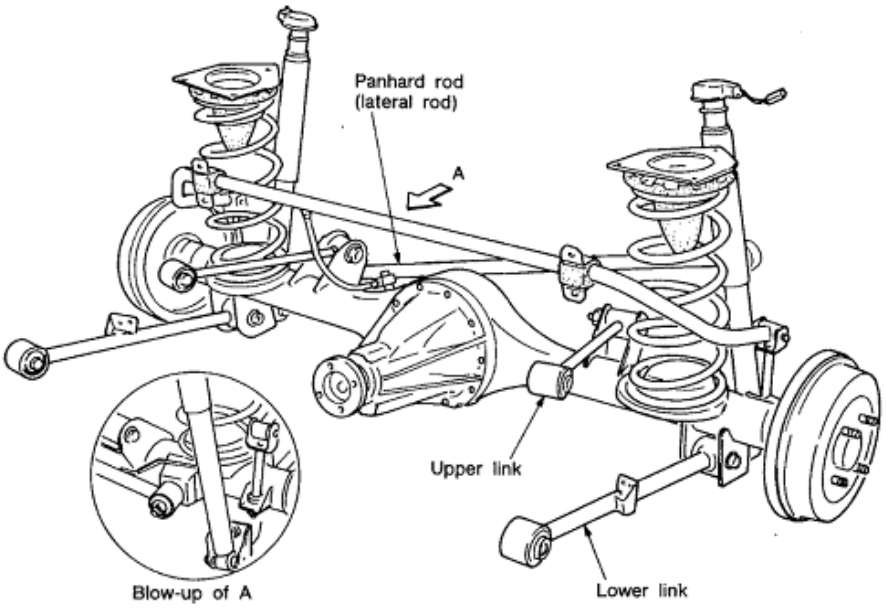



# Suspension

## Rear Suspension

5-Link Coil Spring Suspension

Roll center is lower and bilateral rigidity is higher. There is less lateral movement due to the Panhard rod which makes travelling on rough road more comfortable.



# Suspension

## Suspension Set-up Per Vehicle Model

| Model | | Suspension Set-up |
|---|---|---|
| Isuzu D-Max |  | Front: Independent Double Wishbone<br><br>Rear: Semi-elliptical Leaf Spring |
| Isuzu mu-X |  | Front: Independent Double Wishbone<br><br>Rear: 5-Link Coil Spring Suspension |

# Suspension

## Suspension Set-up Per Vehicle Model: CV

| Model | Suspension Set-up |
|---|---|
| Isuzu QKR77  | |
| Isuzu NLR77   | Front: Multi-leaf Spring<br><br>Rear: Multi-leaf Spring |
| Isuzu NLR85   | |

# Suspension

## Suspension Set-up Per Vehicle Model: CV

| Model | Suspension Set-up |
|---|---|
| Isuzu NMR85   | |
| Isuzu NPR85   | Front: Multi-leaf Spring<br>Rear: Multi-leaf Spring |
| Isuzu NQR75   | |
| Isuzu FRR90   | Front: Multi-leaf Spring<br>Rear: Multi-leaf Spring |

# Suspension

## Suspension Set-up Per Vehicle Model: CV

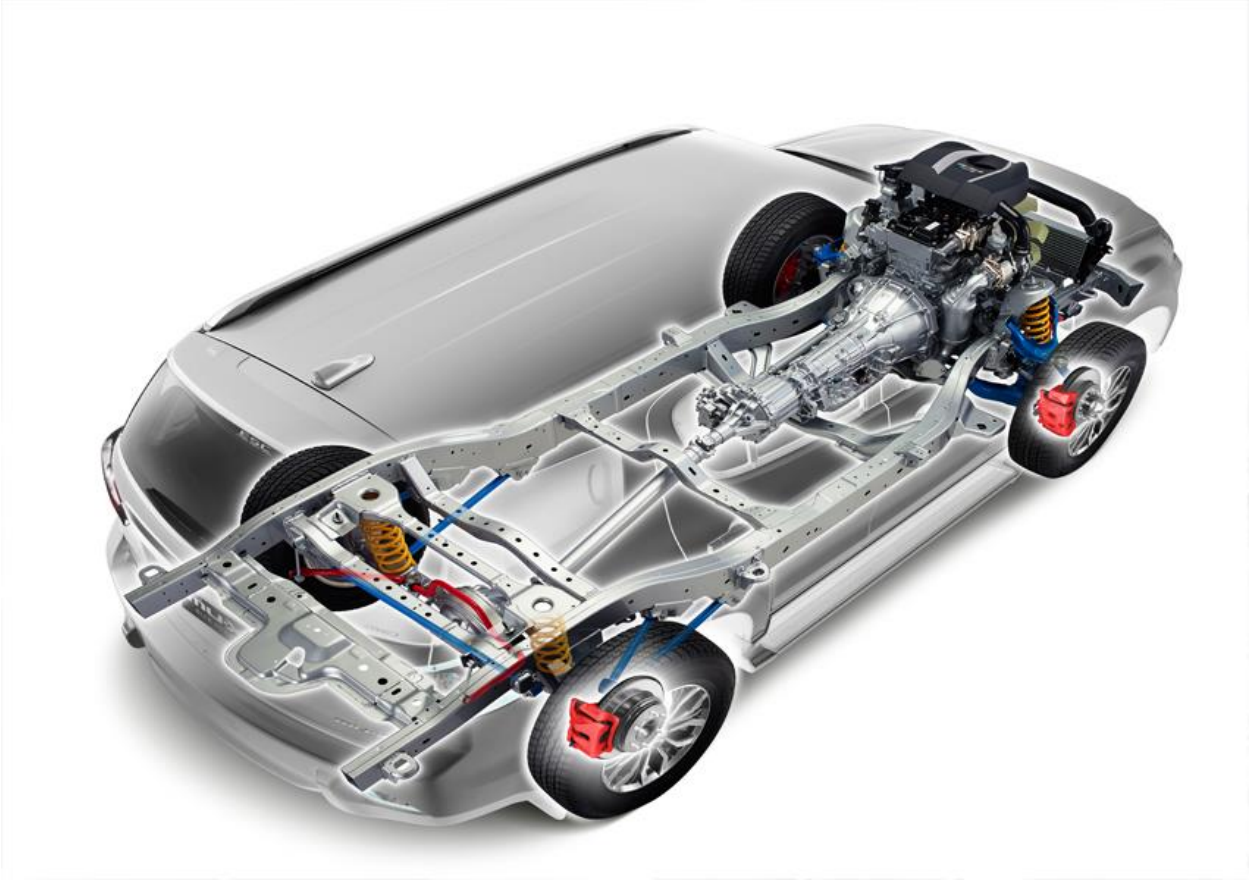
| Model | Suspension Set-up |
|---|---|
| Isuzu FSR34<br>  | Front: Multi-leaf Spring<br>Rear: Multi-leaf Spring |
| Isuzu FVR34<br>  | |
| Isuzu FVM34T<br>  | |
| Isuzu FVM34W<br>  | |

# Suspension

## Suspension Set-up Per Vehicle Model: CV

| Model | Suspension Set-up |
|---|---|
| Isuzu CYZ52  | Front: Multi-leaf Spring<br>Rear: Multi-leaf Spring |
| Isuzu CYH52  | Front: Taper Leaf Spring<br>Rear: Taper Leaf Spring |
| Isuzu EXR52  | Front: Taper Leaf Spring<br>Rear: Multi-leaf Spring |
| Isuzu EXZ52  | Front: Taper Leaf Spring<br>Rear: Taper Leaf Spring |

# Wheel Alignment



# Wheel Alignment

## Introduction

Wheel Alignment is the angle and position with which the wheels are attached to the vehicle body. It is important as it will affect the maneuverability of the vehicle.

Both front and rear wheel can be aligned provided that their suspension systems allow it to do so.



# Wheel Alignment

## Necessity of Wheel Alignment

Although wheel alignment has been performed in the production plant, it is still necessary to perform alignment for the following reasons:

1. Bumping against a curbstone or running off into a gutter

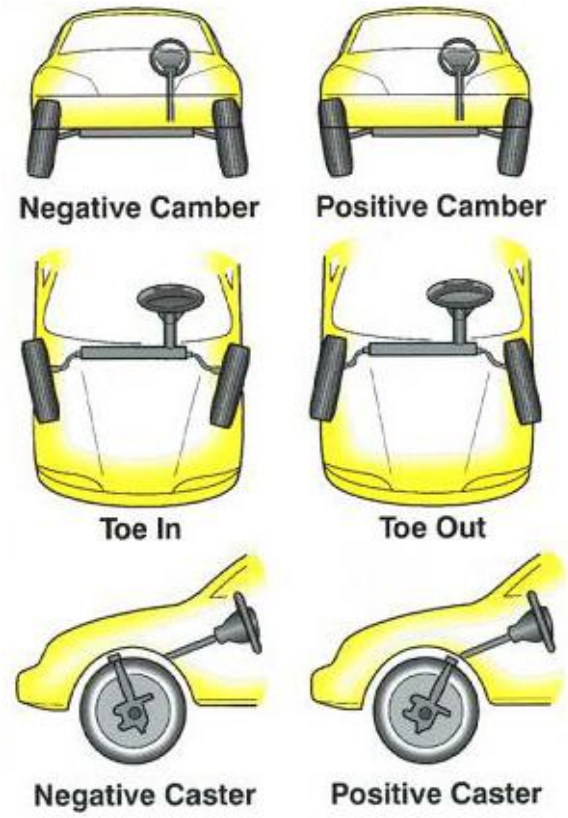
2. Deterioration of rubber bushings, shock absorber or springs.


# Wheel Alignment

## Factors of Wheel Alignment

Below are the following items that need to be considered for front wheel alignment which may affect vehicle running dynamics:

1. Steering Axis Inclination (SAI)
2. Caster
3. Camber
4. Toe



# Wheel Alignment

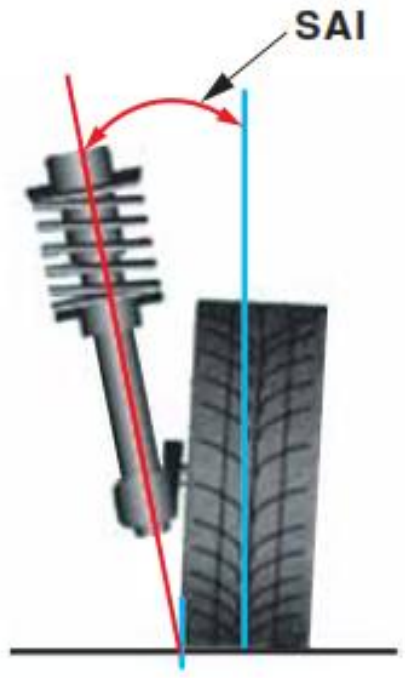
## Factors of Wheel Alignment

Steering Axis Inclination/Kingpin Inclination (SAI)

When viewed from the front of the vehicle, the angle between the kingpin center line and the vertical line is called the Kingpin Inclination.

Purpose:

- To produce returning force on steering system and improve straight-ahead running performance
- Reduce Steering Effort
- Reduce Kickback (impact force to a steering wheel from a tire through a steering system.



# Wheel Alignment

## Factors of Wheel Alignment

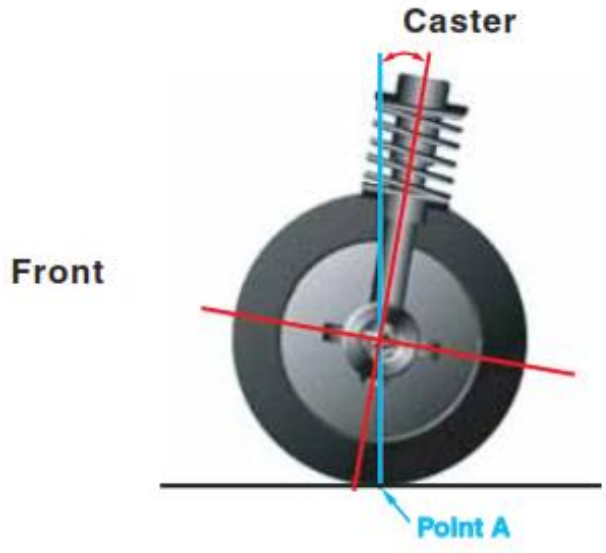
Caster

It is the vertical tilting of the wheel axis either forward or backward (when viewed from the side of the vehicle). A backward tilt is positive and forward tilt is negative.

For Positive tilt, wheel running resistance pulls back to point A, which contributes to straight forward stability known as Caster Effect.

Purpose:

- Improve straight-ahead running performance.
- Reduce steering effort



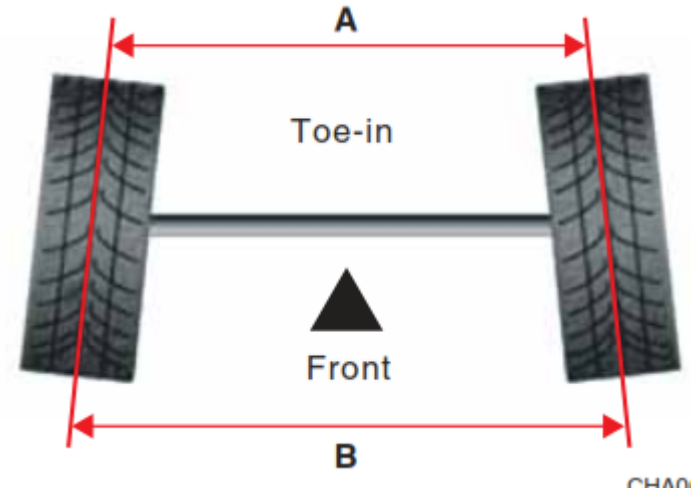
# Wheel Alignment

## Factors of Wheel Alignment

Toe-in, Toe-out

The difference between tread centers on the front of wheels A and tread center of wheels B.

If Distance A is smaller than B, it is called Toe-in, if B is smaller than A, it is called Toe-out.




Purpose:

- Due to camber angle, wheels tend to be toe-out. Toe-in is set to prevent it from happening, maintain straight-ahead stability while driving.

# Wheel Alignment

## Basic Troubleshooting and Maintenance

Inspections Before Wheel Alignment Adjustment

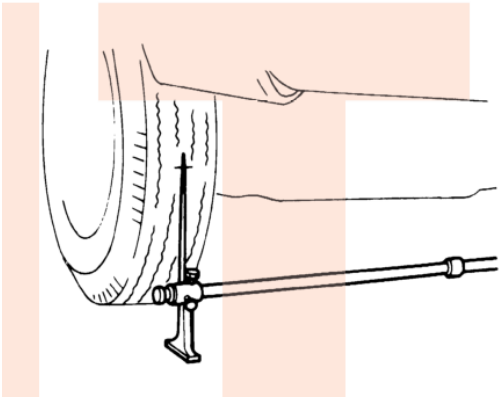
1. Inspect Tire Inflation if adequate.
2. Confirm the unit is not loaded.
3. Confirm spare tire is installed in the right position.
4. Inspect the front wheel bearing to see if the adjustment is adequate.
5. Inspect ball joint and tie rod end. If there is excessive looseness, correct it before making adjustments.
6. Inspect wheels and tires if worn.
7. Inspect trim height. If out of specification, correct it before making caster adjustment.
8. Inspect the steering unit for looseness in the frame.
9. Inspect shock absorber for any leakage or noise.
10. Inspect control arm or stabilizer bar for looseness.

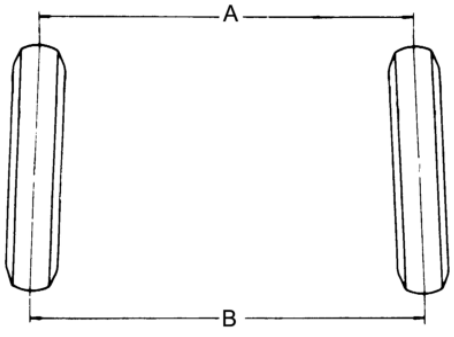
# Wheel Alignment

## Basic Troubleshooting and Maintenance

Toe-in Adjustment

1. Park the vehicle on a level ground.
2. Set steering wheel in a straight ahead position
3. Align toe-in gauge and center height of each wheel at the top.
4. Fit center mark to each wheel to measure distance A between center marks on each wheel.
5. Move vehicle backward slowly until center mark reaches the rear end position.
6. Measure distance B between rear end center marks.
7. Calculate Toe-in: Toe-in = B – A
8. If Toe-in is out of spec, adjust it by loosening the lock nut on tie rod. Rotate nuts by the same amount to maintain steering wheel center position.



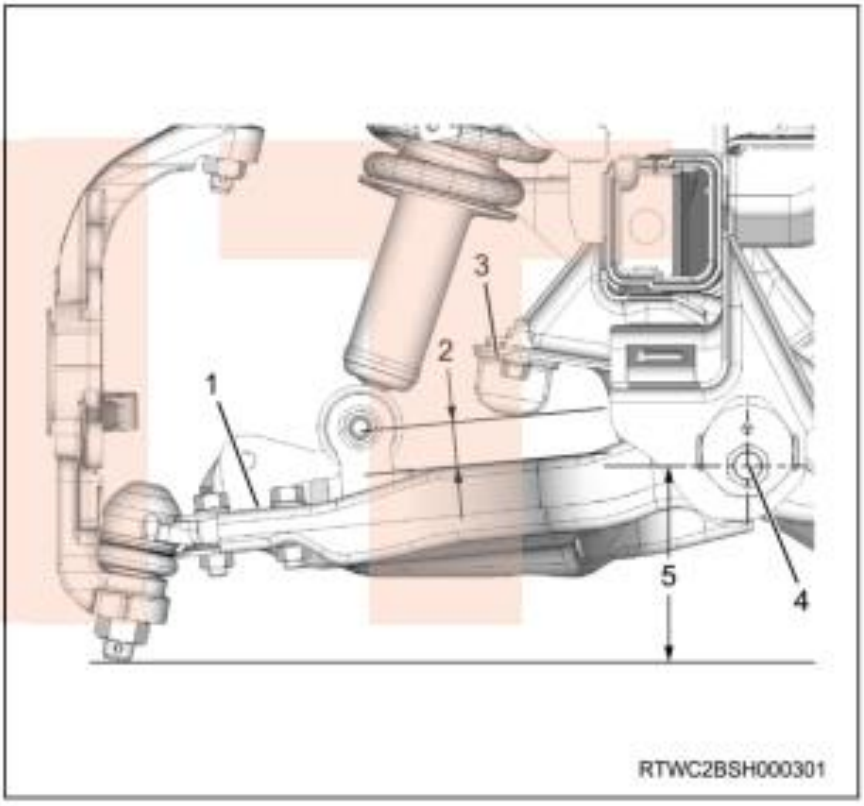


# Wheel Alignment

## Basic Troubleshooting and Maintenance

Front Trim Height Inspection (Isuzu D-Max)

| 2WD (Except for High Ride Suspension) | |
|---|---|
| Trim Height | 114 mm (4.49 in) |
| Buffer Clearance | 25.9 mm (1.02 in) |



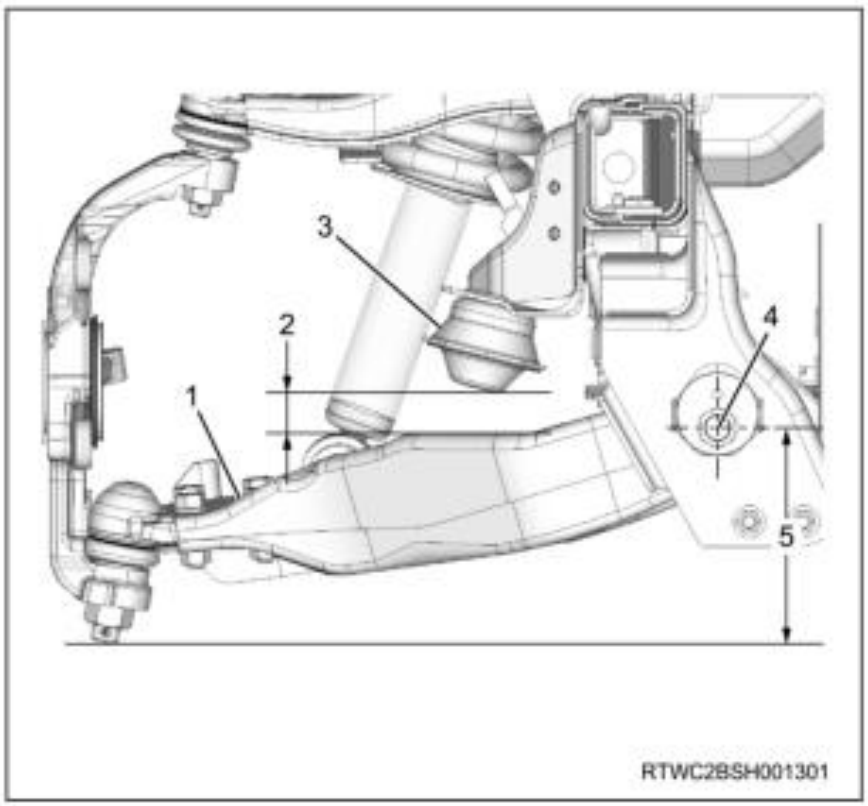

1. Lower control arm
2. Buffer clearance
3. Bumper rubber
4. Rear side cam bolt center
5. Trim height

# Wheel Alignment

## Basic Troubleshooting and Maintenance

Front Trim Height Inspection (Isuzu D-Max)

| 2WD & 4WD (High Ride Suspension) | |
|---|---|
| Trim Height | 114 mm (4.49 in) |
| Buffer Clearance | 25.9 mm (1.02 in) |



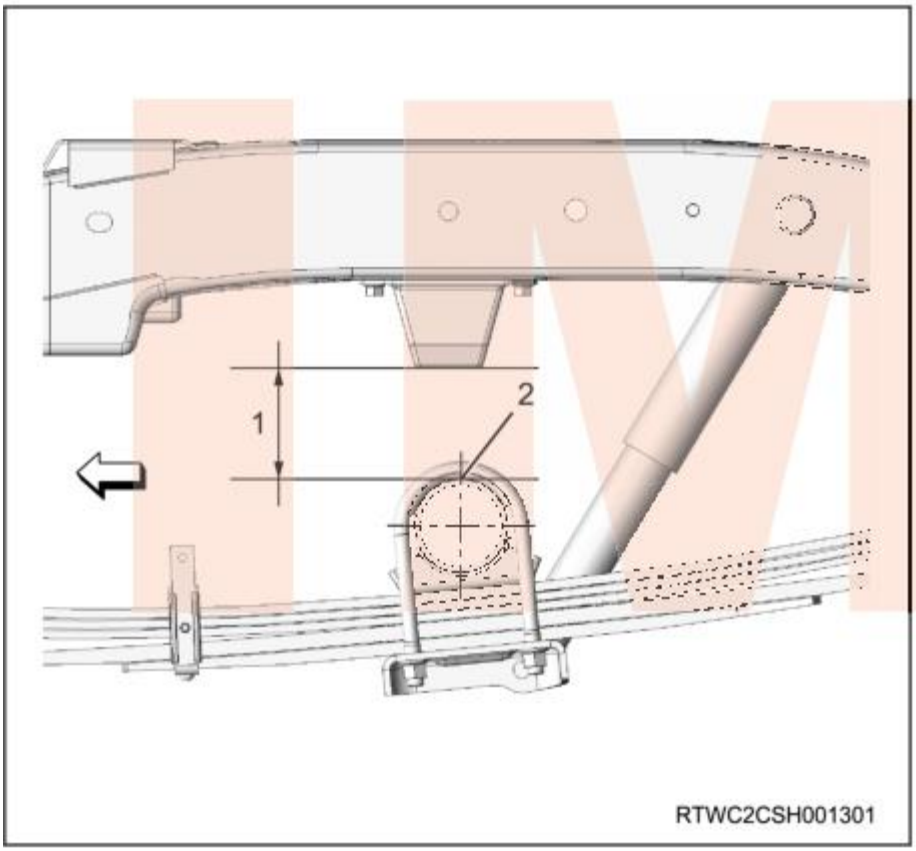

1. Lower control arm
2. Buffer clearance
3. Bumper rubber
4. Rear side cam bolt center
5. Trim height

# Wheel Alignment

## Basic Troubleshooting and Maintenance

Rear Buffer Clearance (Isuzu D-Max)

| | |
|---|---|
| 2WD (Except for High Ride Suspension) | 92 mm (3.62 in) |



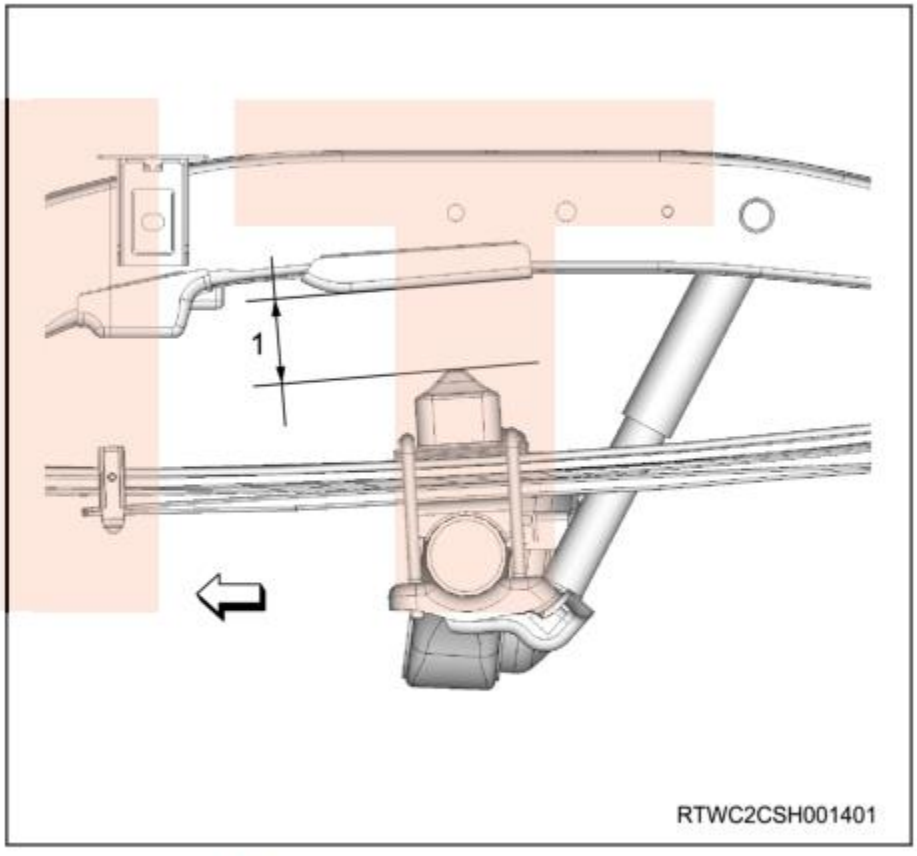

1. Buffer clearance
2. Top of the seat

# Wheel Alignment

## Basic Troubleshooting and Maintenance

Rear Buffer Clearance (Isuzu D-Max)

| | |
|---|---|
| 2WD & 4WD (High Ride Suspension) | 83 mm (3.27 in) |



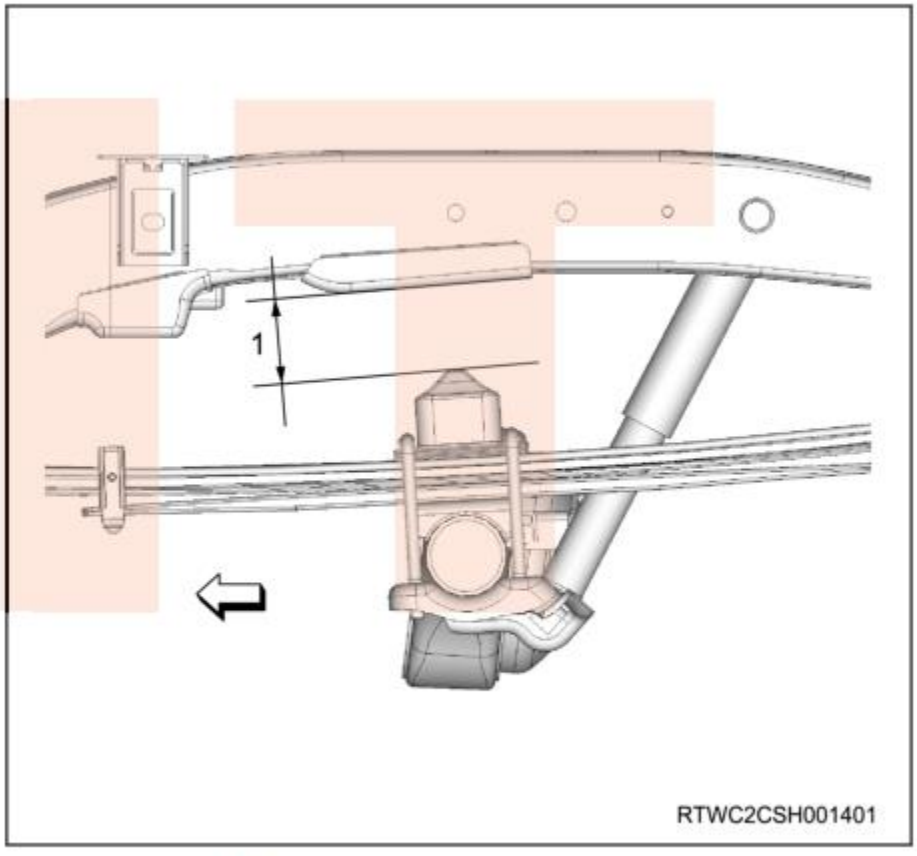

1. Buffer clearance

# Wheel Alignment

## Basic Troubleshooting and Maintenance

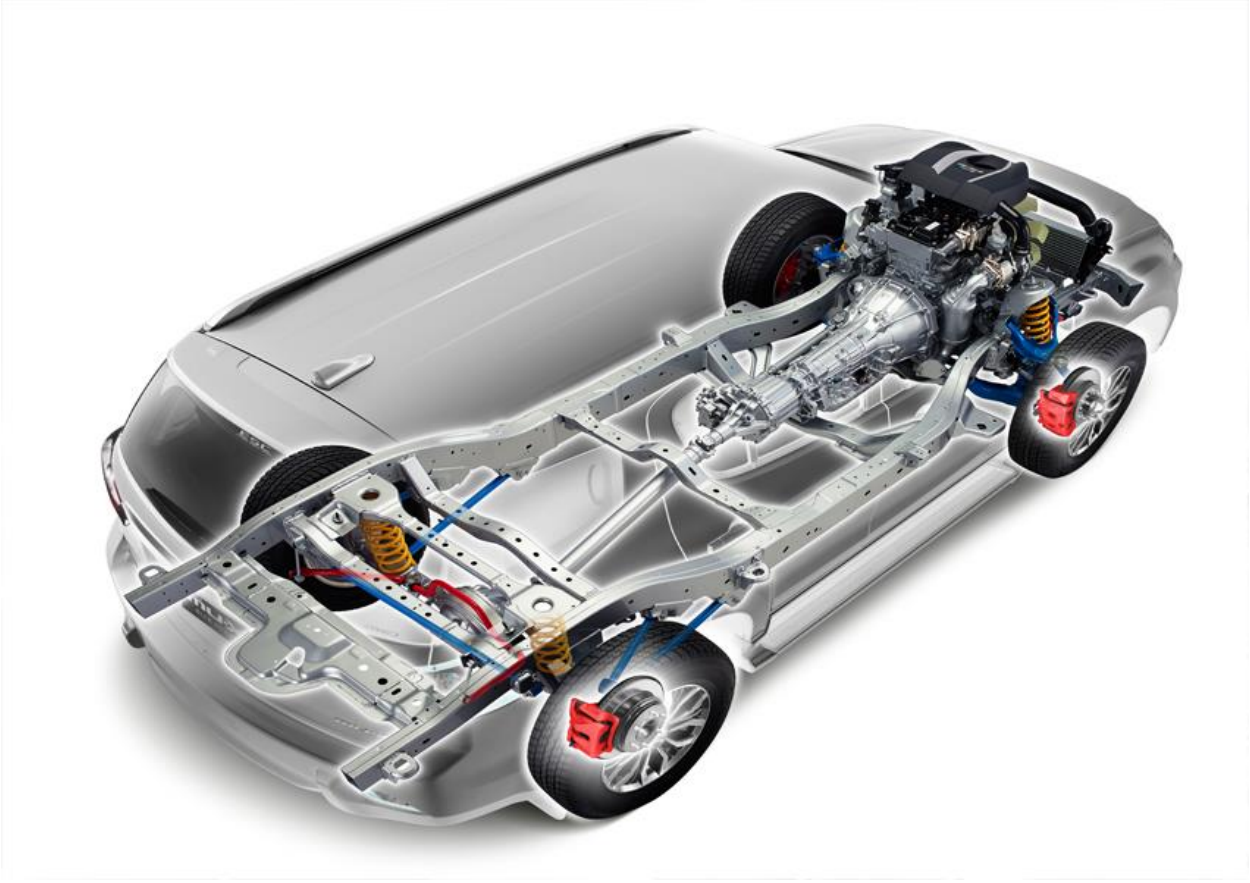
Rear Buffer Clearance (Isuzu D-Max)

| | |
|---|---|
| 2WD & 4WD (High Ride Suspension) | 83 mm (3.27 in) |




1. Buffer clearance

# Brakes



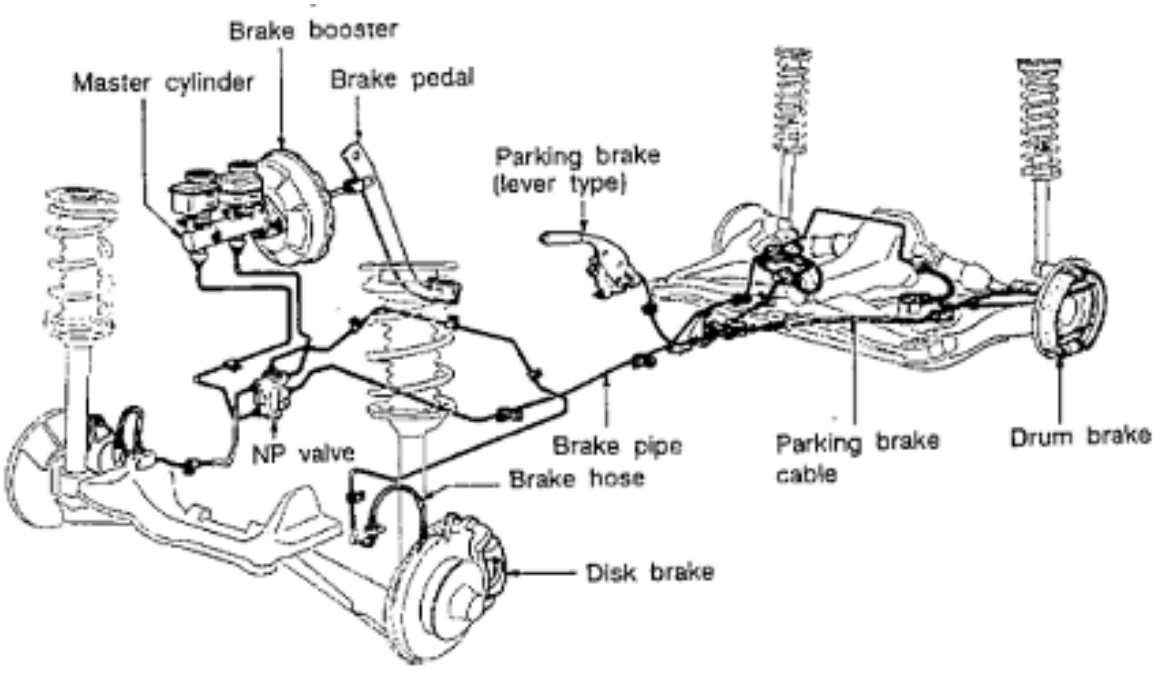
# Brake System

## Introduction

The brake system is the most fundamental safety feature on a modern automobile. It allows the vehicle to slow down or stop the vehicle when applied. It does this by converting movement energy to heat energy using friction.

Brake systems must have the following features:

- Operation must completely effective.
- The system must be of superior reliability and durability.
- Inspection and adjustment must be easy.

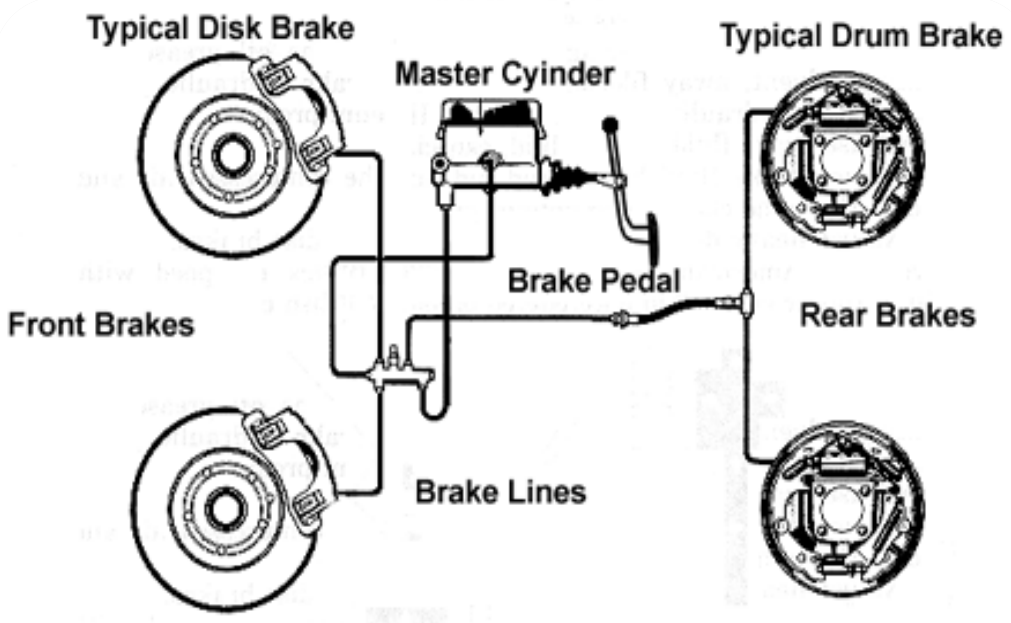


# Brake System

## Types of Brakes

Service Brakes (Foot Brake)

The rotation of the wheels is controlled by hydraulic fluid or air pressure whenever the brake pedal is depressed.



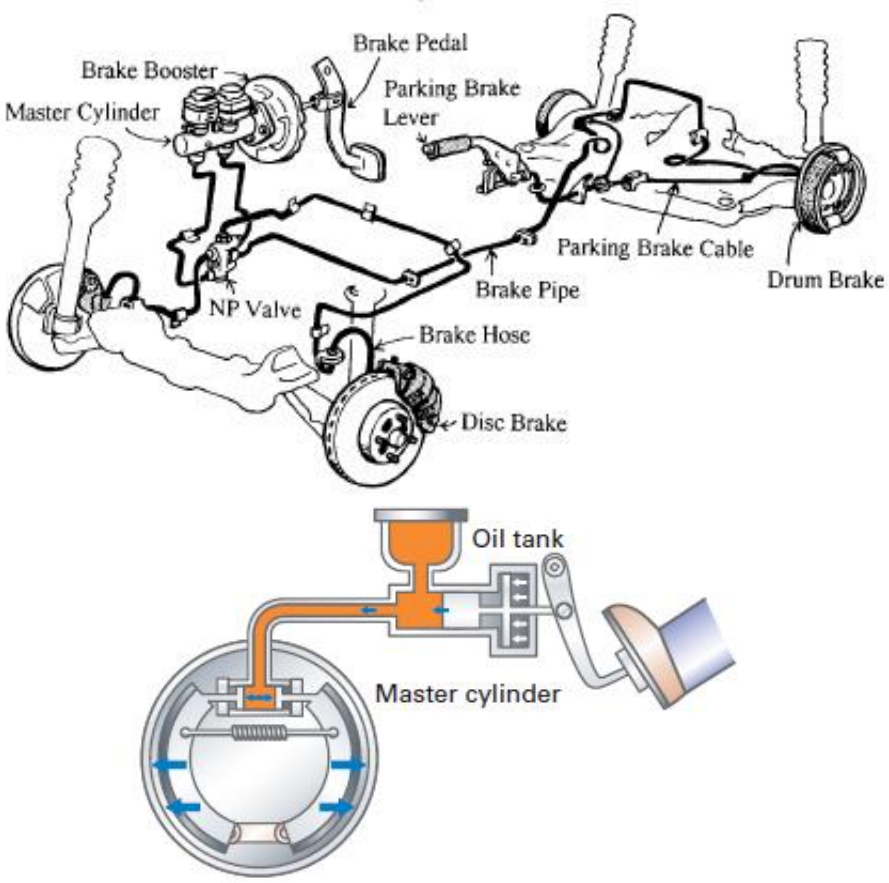

Typical Automotive Braking System

# Brake System

## Types of Brakes

Types of Service Brakes

Hydraulic Brakes – it is a type of service brakes in which it uses a hydraulic fluid to transmit input (depressing force) directly to output parts (wheel cylinders) and at the same time, boost it proportionally by the external force (vacuum or compressed air). This type is commonly used in passenger cars and small trucks.



# Brake System

## Types of Brakes

Types of Service Brakes

Parts of Hydraulic Brake System:

Brake Pedal – Controlled by the driver's foot, it converts this force into hydraulic pressure.

Brake Booster – It boosts the force that acts on the master cylinder based on pedal effort applied by the driver.

Master Cylinder – Converts pedal action into hydraulic pressure. It consists of reservoir which stores brake fluid and a cylinder that generates hydraulic pressure.

# Brake System

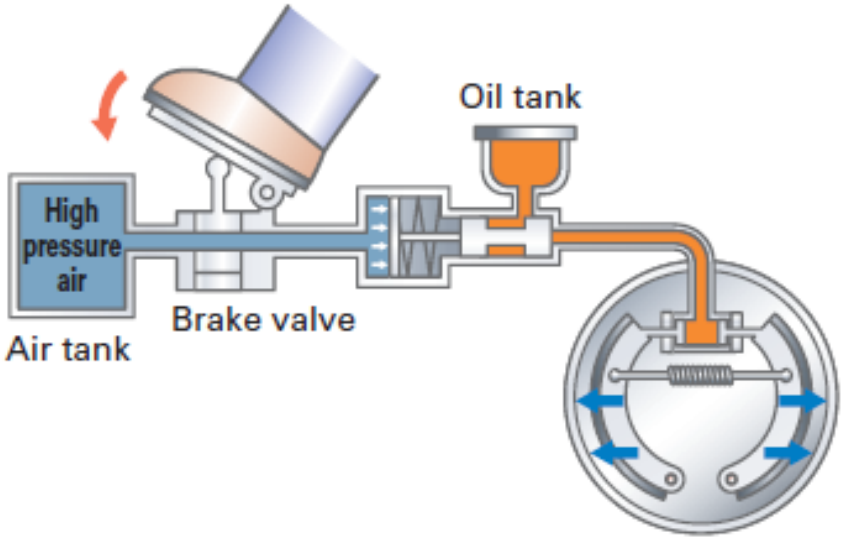
## Types of Brakes

Types of Service Brakes

Air Brakes – It uses compressed air as a medium in order to effect braking action.

Types of Air Brakes:

Air-Over-Hydraulic Brakes – A combination of compressed air and hydraulic pressure in a circuit. It controls air pressure using brake valve which then converts the air pressure to hydraulic pressure and applies it to the brake. Mostly used in medium duty trucks.



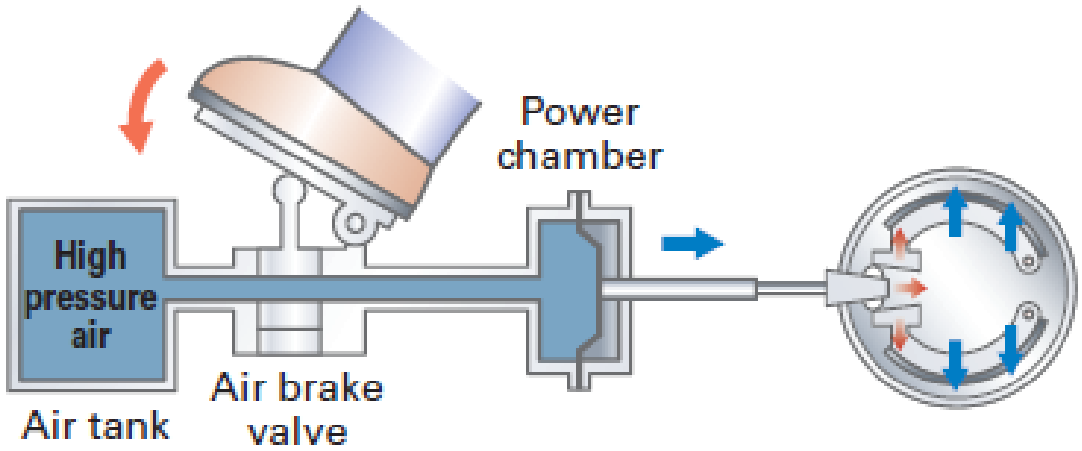
# Brake System

## Types of Brakes

Types of Service Brakes

Types of Air Brakes:

Full Air Brakes – It uses compressed air generated by the compressor as medium to force the brake shoes to contact the brake drum. Mostly used from medium to heavy duty trucks.



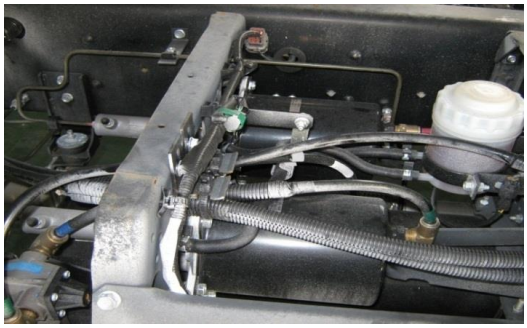
# Brake System

## Types of Brakes

Types of Service Brakes

Basic Components of Air Brakes

Brake Valve – A control valve which operates when the brake pedal is depressed, and supplies air pressure to the relay valves



Brake Air Master – utilizes the difference between atmospheric pressure and compressed air to activate the piston to deliver fluid pressure to wheel cylinders.

Air Compressor – operated by the engine, compresses air and supplies it to the air tanks.

# Brake System

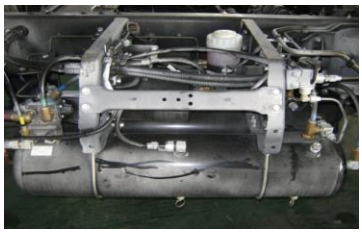
## Types of Brakes

Types of Service Brakes

Basic Components of Air Brakes

Air Dryer– removes moisture from air using dessicants

Air Tank – A reservoir which acts to maintain air pressure generated by the air compressor



Air Governor – It sends pressure to the control port to open the drain valve of the air dryer when the outlet port pressure reaches pre-determined pressure.

# Brake System

## Types of Brakes

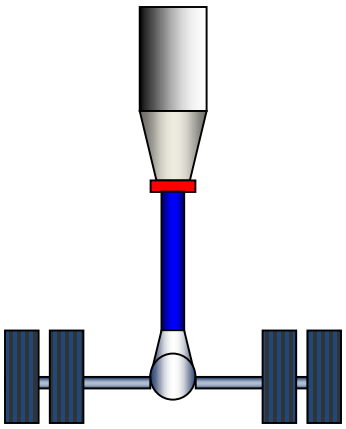
Parking Brake

The parking brake is used for keeping the vehicle stationary. It is also called emergency braking to stop the vehicle when a foot brake fails during driving.

Types of Parking Brakes:

a. Expansion Type Handbrake

b. Center Parking Type



# Brake System

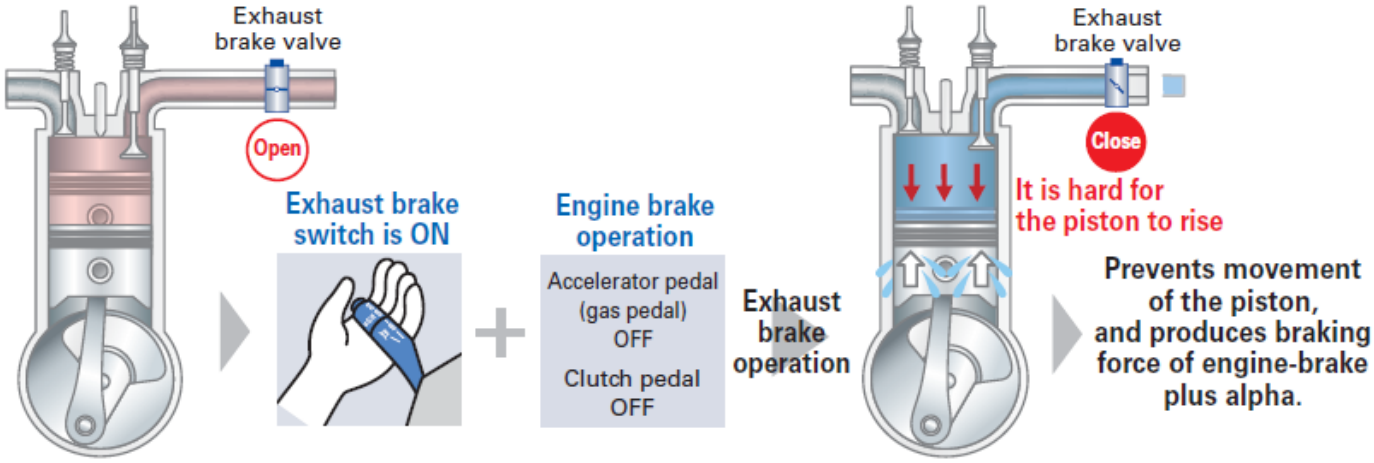
## Types of Brakes

Auxiliary Brake

It is used to decelerate a motor vehicle. It plays the role of preventing wheel brake fading and increased effectiveness of braking.

Types of Auxiliary Brake:

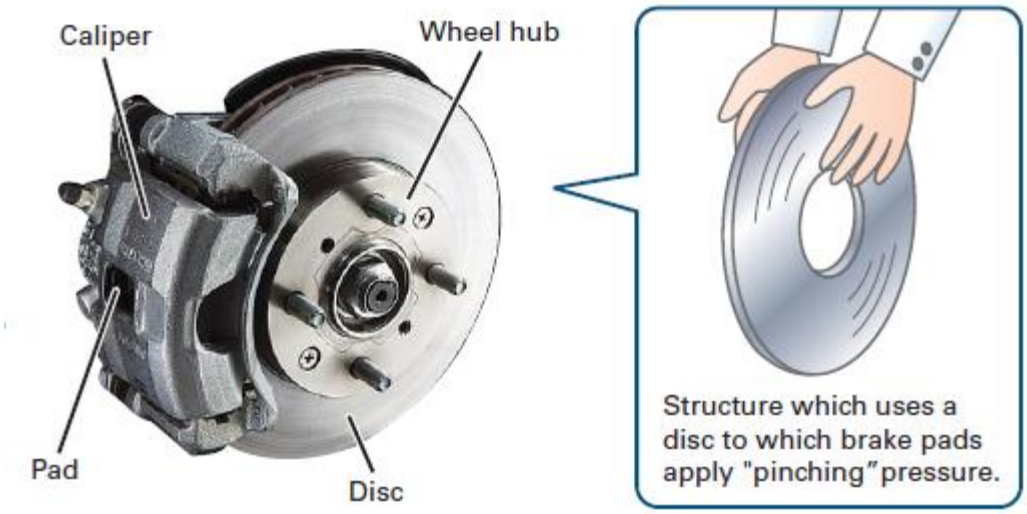
Exhaust Brake – A device the uses a valve to restrict the exhaust system, forcing the engine to work harder on the exhaust stroke.



# Brake System

## Disc Brakes

It has a metal disc or rotor instead of a drum. It uses a pair of flat, lined pads that are forced against the rotating disc to produce braking.



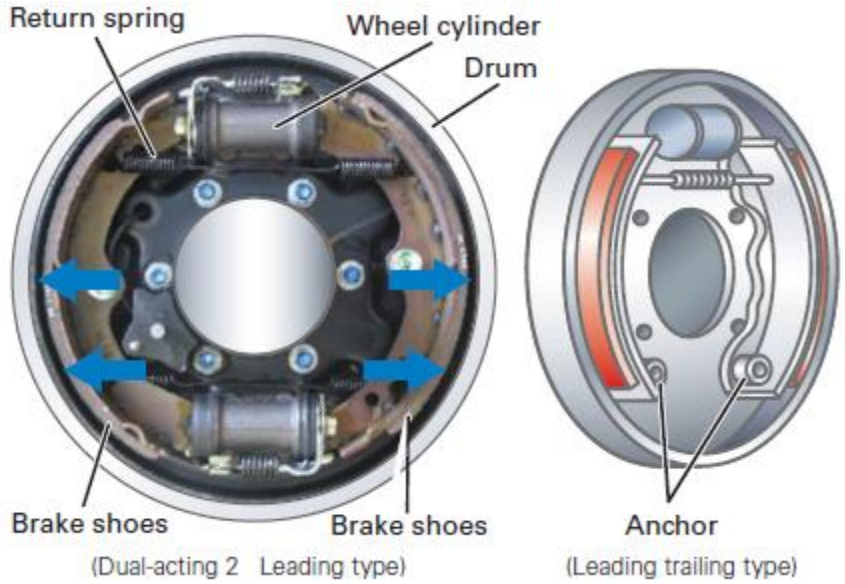

Components of Disc Brake

- Rotor Disc
- Brake Caliper
- Brake Pads

# Brake System

## Drum Brakes

It has a metal brake drum that encloses the brake assembly at each wheel. Two curved brake shoes expand outward to slow or stop the brake drum which rotates with the wheel.



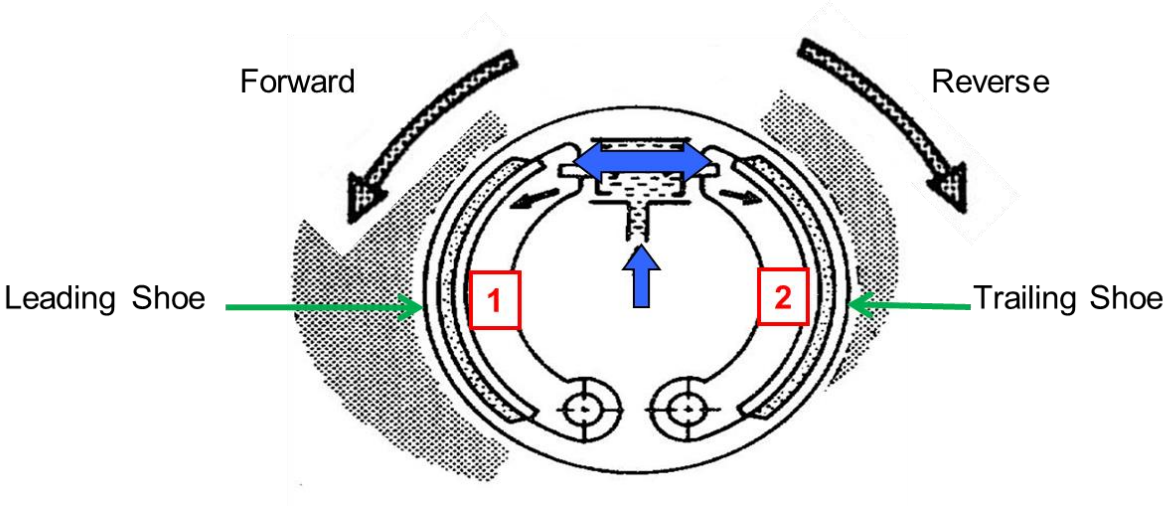

Types of Brake Servo Action

- Leading/Trailing Type
- Two Leading Type

# Brake System

## Leading and Trailing Type

This type is widely used because of structural simplicity and easy maintenance. However, efficiency is low as indicated by the surface pressure distribution. For this reason, leading and trailing type shoes are often combined with booster system for heavy trucks and buses.



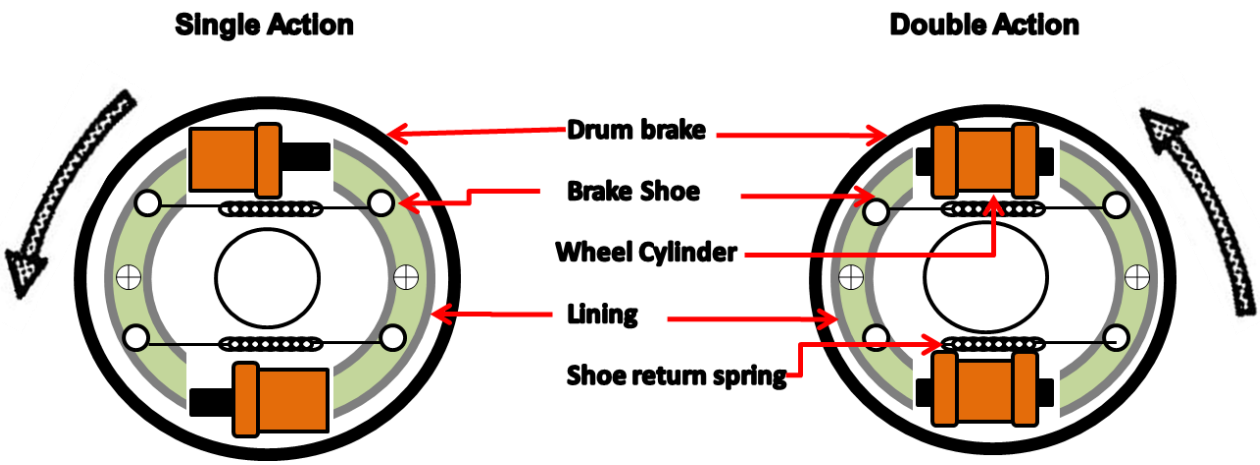

**Advantages of Leading and Trailing Type**

- Braking force is steady
- Low Cost
- Brake is provided on both forward and reverse stops

# Brake System

## Two Leading Type

In two leading type, shoes of this type are combined with either a single or a double acting wheel cylinder. The two leading configuration has two (2) wheel cylinder, both of which are fixed on the brake shoe bracket.




Advantage:

- In case of forward direction, both servo can get self servo action.

Disadvantage:

- When in reverse direction, both brake shoes cannot get self-servo action.

# Brake System

## Brake Fluid

It is a chemically-inert hydraulic fluid used to transmit force and motion. It also lubricates the pistons in the master cylinder, wheel cylinders and calipers.

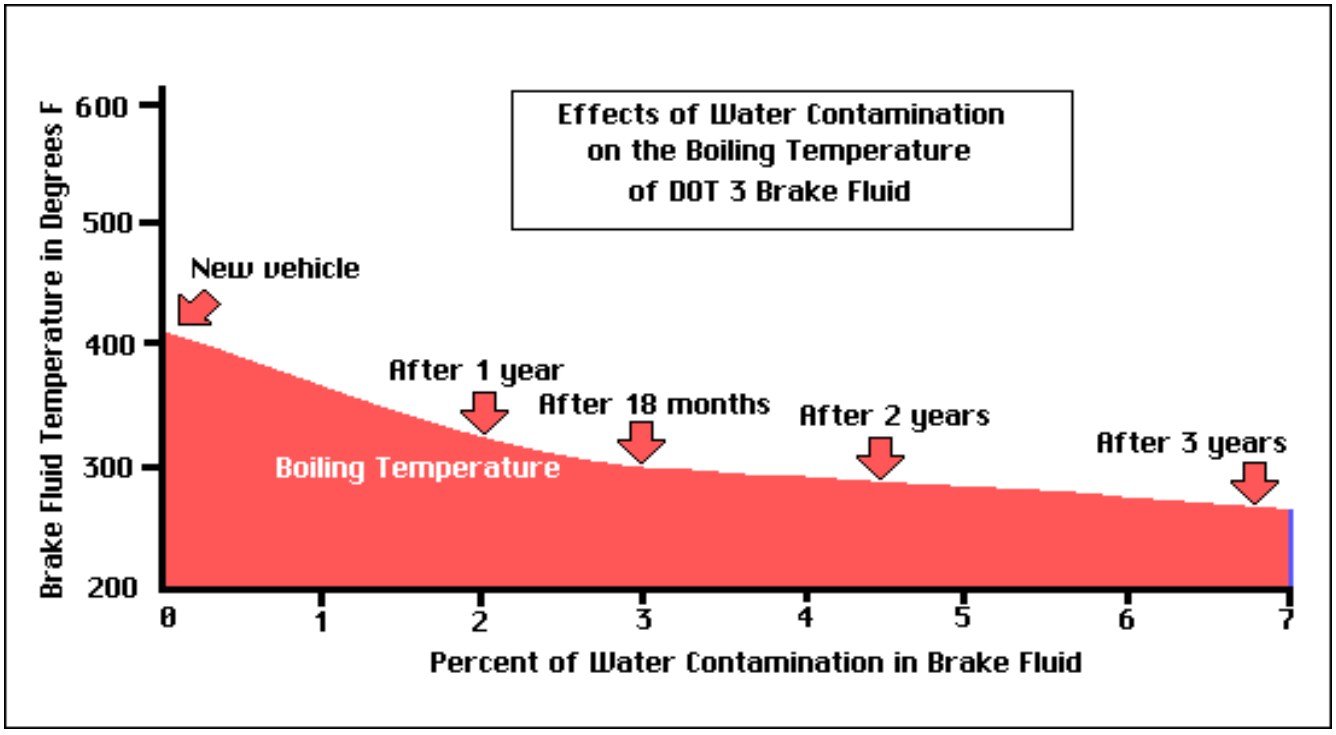
Classification of Brake Fluid

| Property | DOT 3 | DOT 4 | DOT 5 |
|---|---|---|---|
| Boiling Point (°C) | 205 | 230 | 260 |
| Wet Boiling Point (°C) | 140 | 155 | 180 |
| Main Component | Ether Glycol Based | Ether Glycol / Borate Ester | Silicon Based |

- If your vehicle was designed for a particular type of fluid, you should make every attempt to stick with that fluid.
- If your vehicle was designed to be DOT 3 fluid specification, the internal components of the system (seals, brake hoses, and fittings) were specifically designed and tested for compatibility with DOT 3 because DOT 4 and DOT 5 fluid contain a different chemical composition.

# Brake System

## Brake Fluid



# Brake System

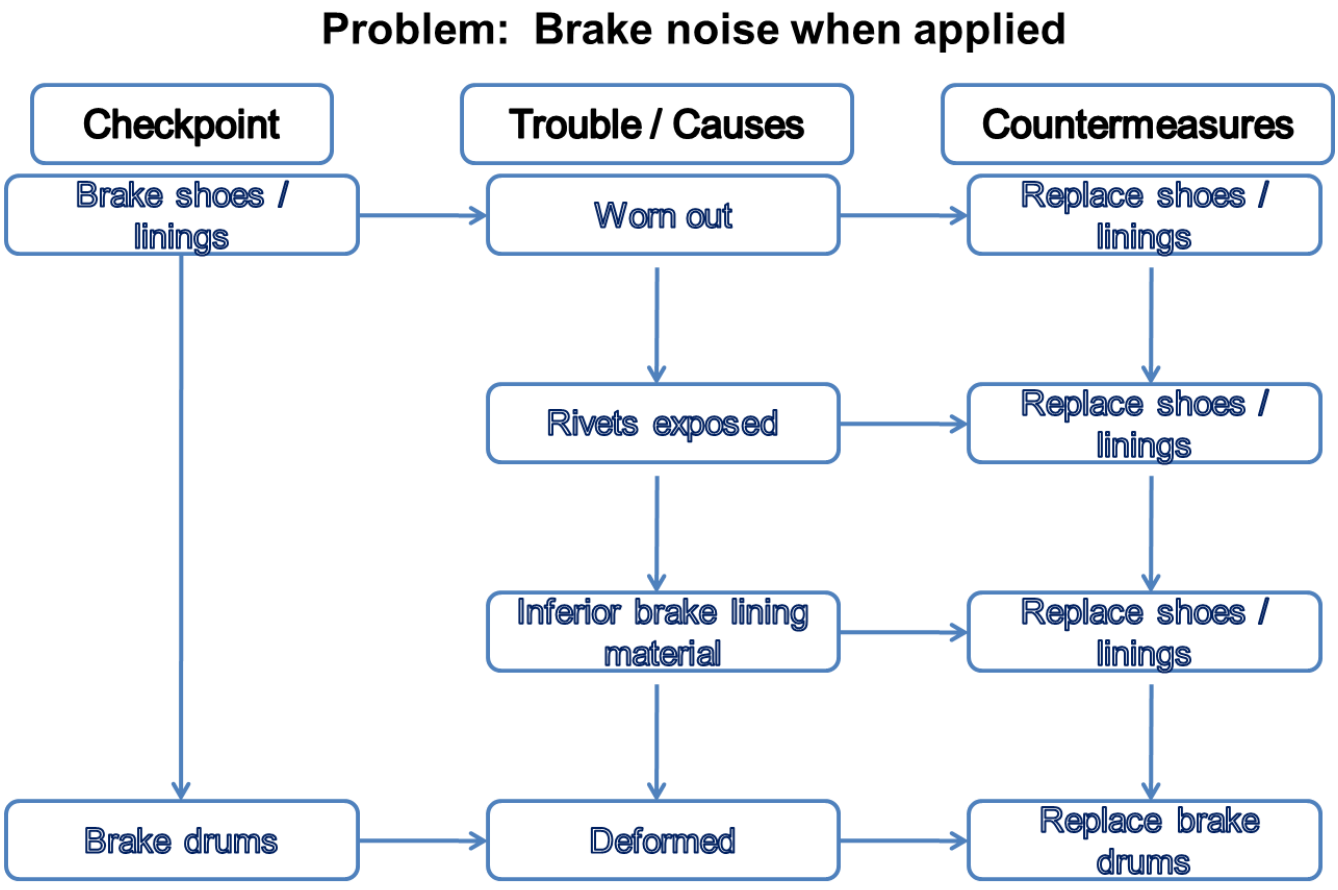
## Basic Troubleshooting and Repair

**Problem: Poor Braking Action**

| Checkpoint | Trouble / Causes | Countermeasures |
|---|---|---|
| Brake Fluid | Insufficient | Replenish |
| Hoses and Pipes | Fluid Leakage | Repair |
| Brake shoe | Excessive Clearance | Adjust |
| Master Cylinder Cup | Damaged | Replace |
| Wheel Cylinder Cup | Damaged | Replace |
| Brake drums | Soaked with fluid | Wash and Dry / Replaced Lining |
| Brake Linings | Worn Out | Replace linings |

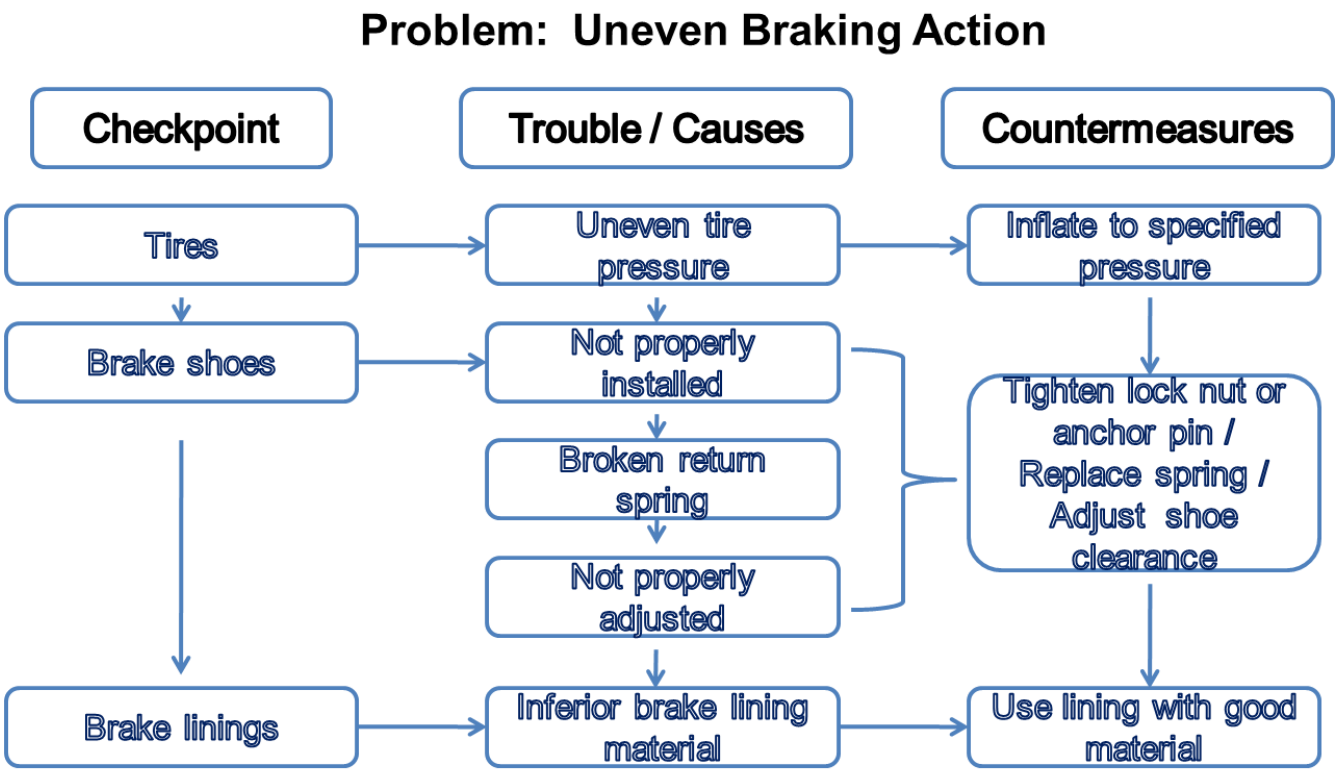
# Brake System

## Basic Troubleshooting and Repair



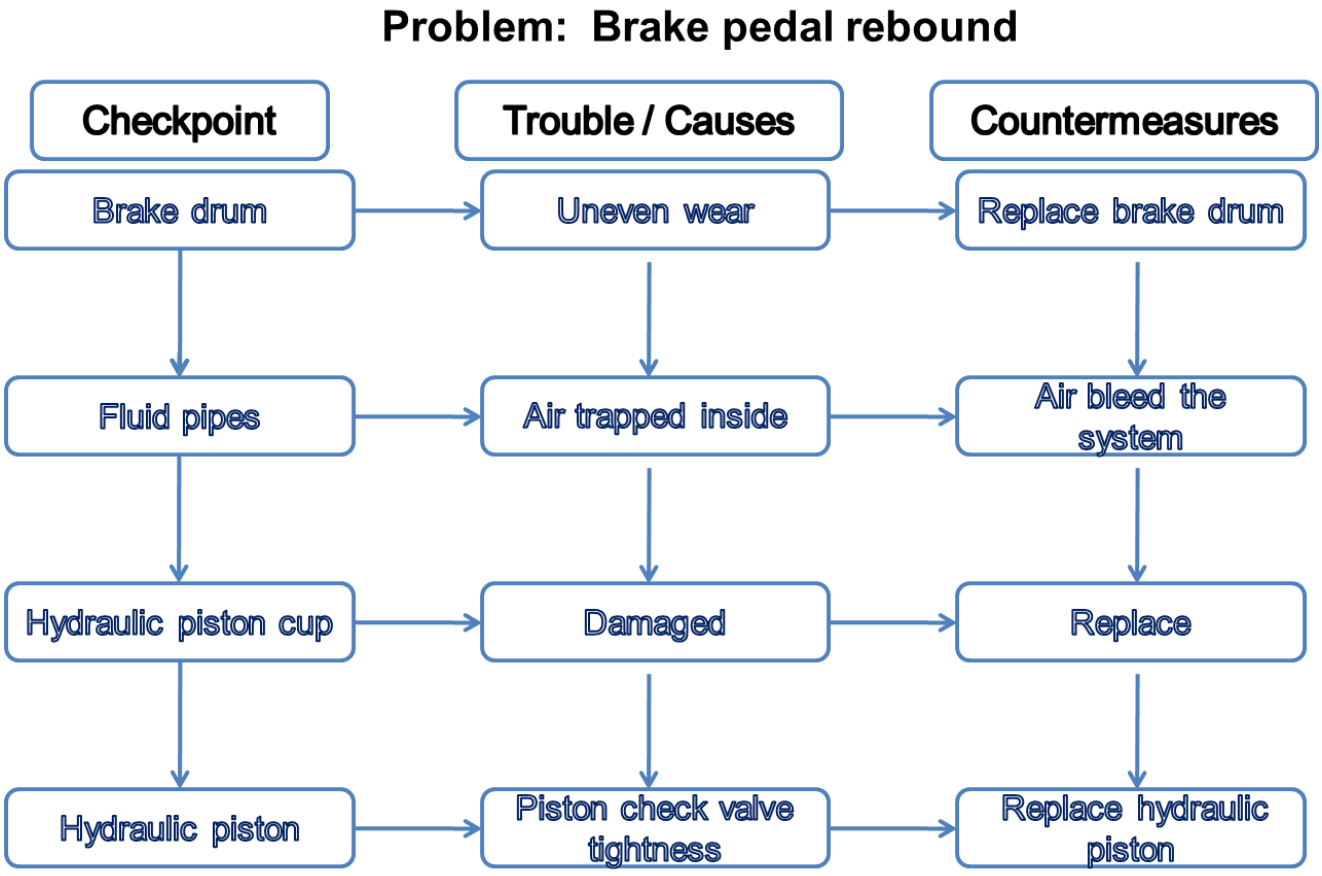
# Brake System

## Basic Troubleshooting and Repair

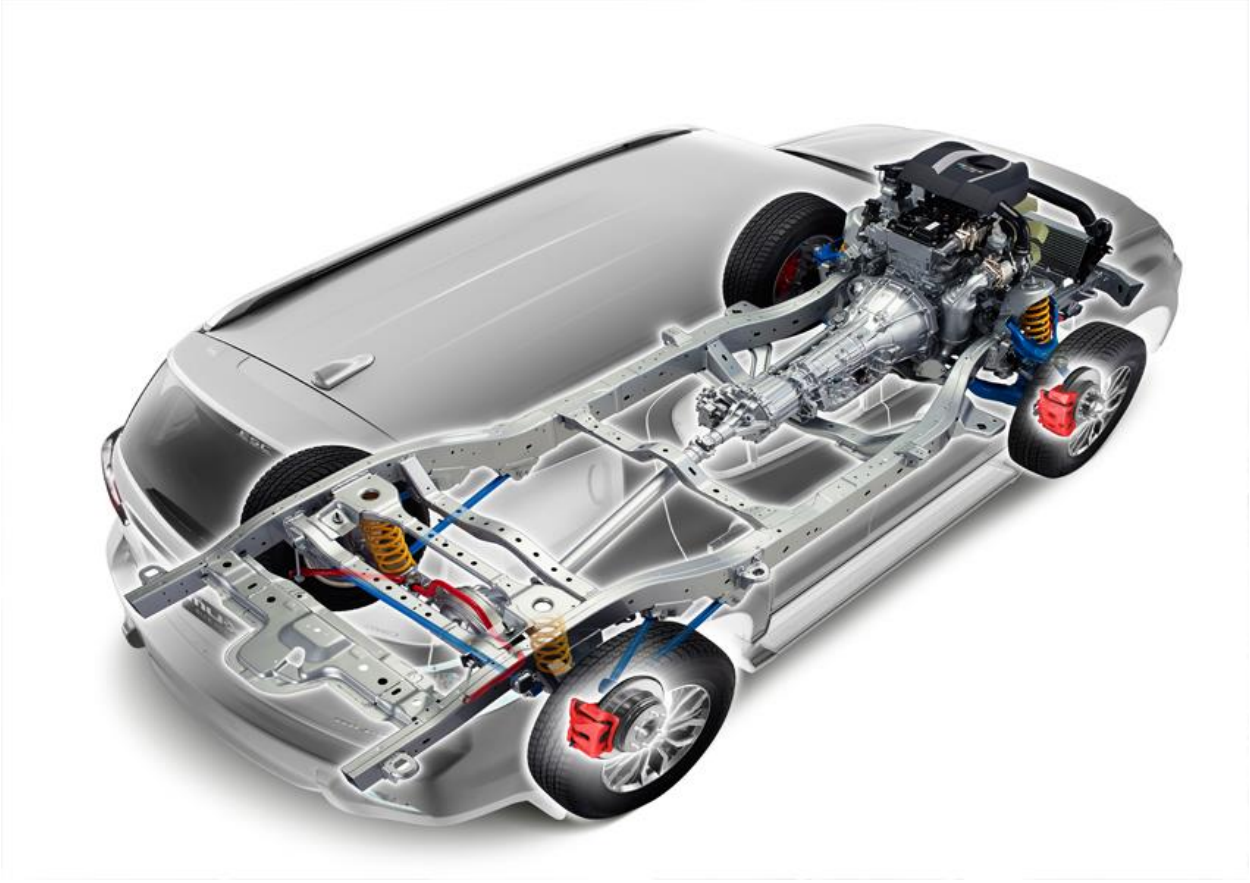


# Brake System

## Basic Troubleshooting and Repair



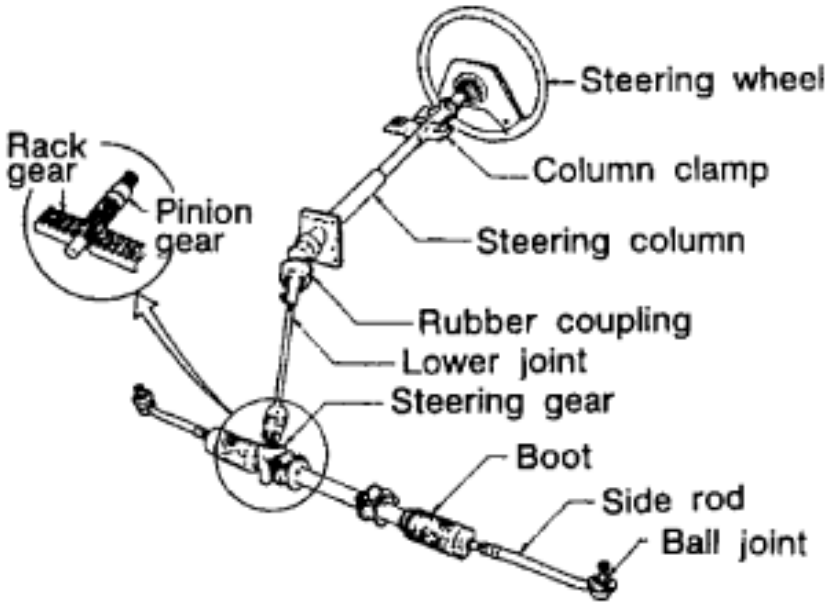
# Steering



# Steering

## Introduction

The steering system determines the direction the vehicle moves. The system is responsible for the smooth, stable and, most importantly, the safe steering of the vehicle. It must be sturdy and completely reliable.



# Steering

## Types of Steering Box

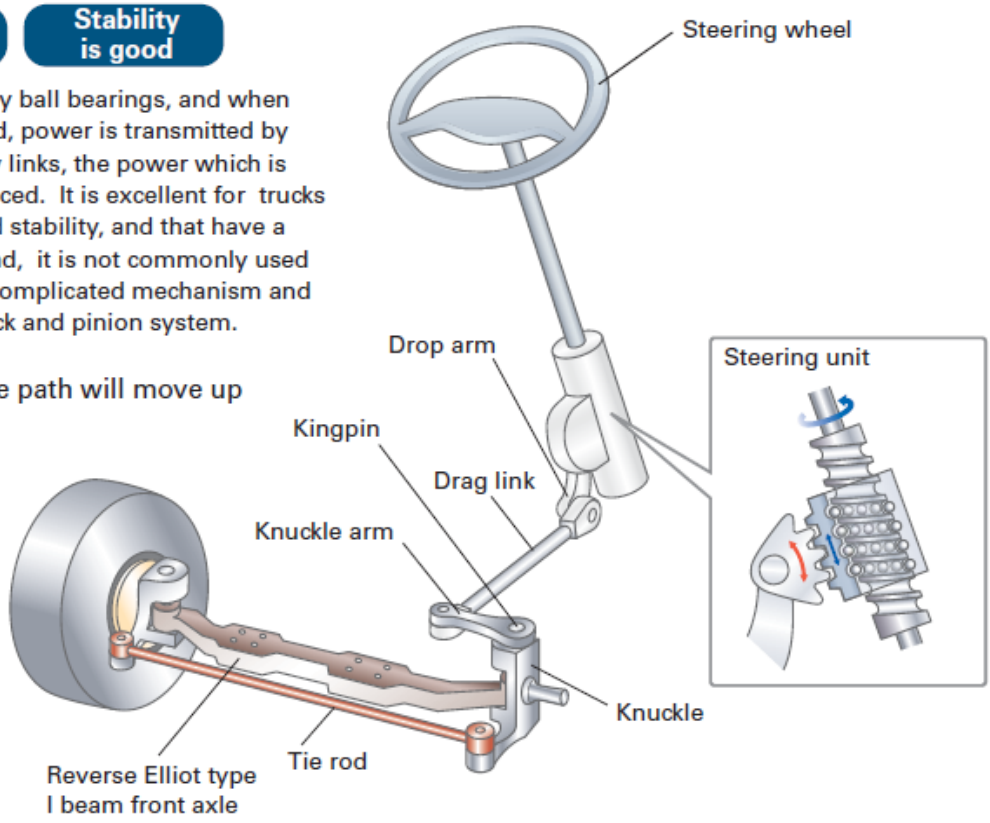
**Ball nut type**

### Steering effort is light, and standard for a truck

**Steering effort is light** | **Holding effort is good** | **Stability is good**

Steering gear(nut) is filled with many ball bearings, and when the handle (steering wheel) is turned, power is transmitted by the rolling ball bearings. With many links, the power which is necessary for operation can be reduced. It is excellent for trucks that require good steering effort and stability, and that have a heavy axle weight. On the other hand, it is not commonly used for passenger cars, because of the complicated mechanism and weight increase compared to the rack and pinion system.

❶Balls arranged in a spiral shape path will move up and down when the steering wheel is turned
❷Piston moves up and down
❸Drop arm moves forward and backward
❹Drag link moves forward and backward
❺Knuckle arm moves forward and backward
❻Knuckle rotates around the kingpin, right tire moves
❼Tie rod moves right and left
❽Left tire moves



# Steering

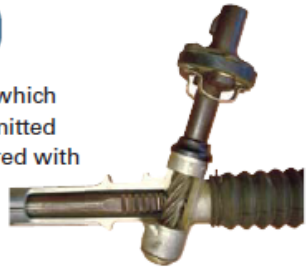
## Types of Steering Box

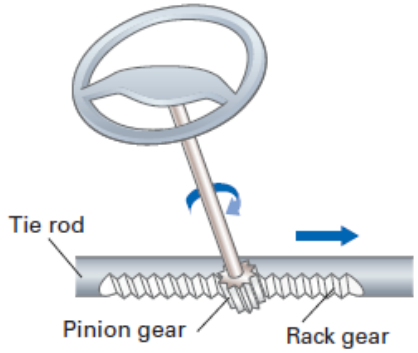
### Rack & pinion type

**Simple and lightweight mechanism, used in passenger cars - Standard for light trucks**

There is little space for interplay | Crisp steering response | Simple and lightweight mechanism

The steering gear is directly connected with the tie rod which supports both wheels. The rotation of the gear is transmitted directly to the tie rod, which moves the wheels. Compared with the ball nut type, it is lightweight and inexpensive.






### Power steering

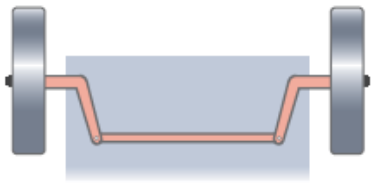
**Operating force required for turning the steering wheel is light because of hydraulic pressure.**

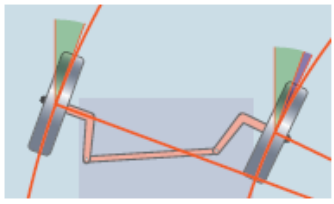
This is the mechanism by which the handling (steering) operation is made light and easy, due to the existence of the hydraulic force pump run by the engine. It is also unsusceptible to the conditions of the road surface (unevenness, etc.), because the hydraulics can absorb impact from the road surface. Without power steering, the steering wheel is heavy and hard to move when stopped. With power steering, the steering is light and the driver can easily maneuver even in tight areas such as a parking garage. When the engine stops, the power steering is not available because the hydraulics are shut off.

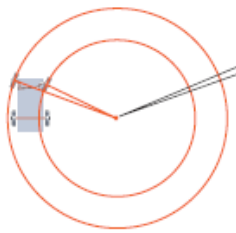
### Ackerman Link

By the trapezoid-shaped link, the mechanism makes the steering angle of the steering wheel set to increase inside and to decrease outside. There is one pivot point, which makes smooth turning possible. This concept is named after the individual, "Ackerman", who invented it.

**Trapezoid-shaped link = Ackerman Link...** Turning angle of the inside tires increases



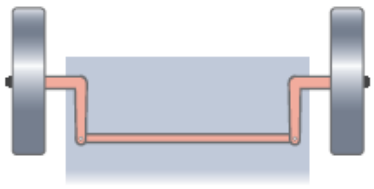


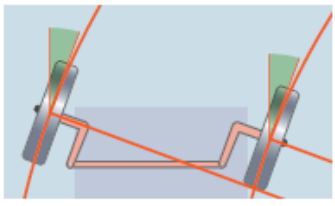


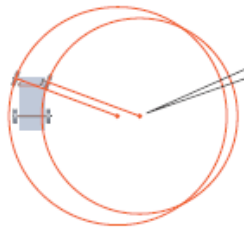
There is one rotation center/pivot point

Able to turn without slipping away from the fixed circumference

**If a link is parallelogram-shaped...** Turning angle of the inside and outside tires are the same







Turning center is different for the inside and outside wheels

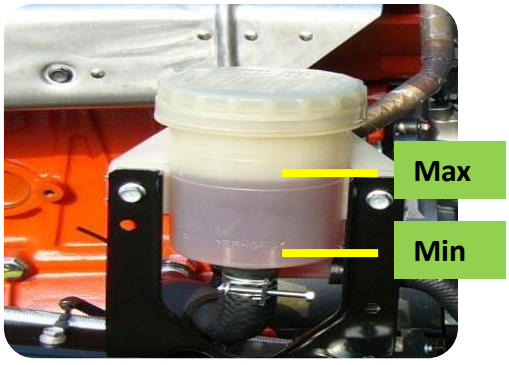
The center is gradually shifted at each turn

# Steering

## Servicing, Troubleshooting and Maintenance

Refilling of Steering Fluid

a. Connect the fluid lines securely and fill the reservoir with specified steering fluid
b. When the fluid reservoir is filled to the specified level, allow two (2) or three (3) minutes. While refilling, keep fluid reservoir replenished as necessary to prevent air from entering the hydraulic system.
c. Start and let the engine idle for a few minutes . Re-check the fluid level and replenish, if necessary steering fluid.

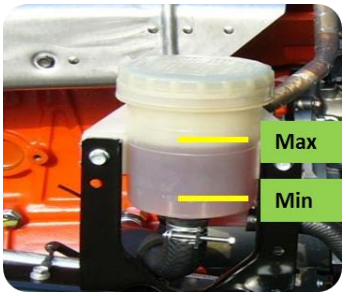



# Steering

## Servicing, Troubleshooting and Maintenance

### Air Bleeding of Steering System

a. Fill fluid reservoir with specified steering fluid and turn the steering wheel to lock in both directions repeatedly, so that level of fluid in the reservoir lowers.
b. Fill to bring the level of fluid in the reservoir to the specified level and start the engine.
c. Perform the following check with the engine running at idle.
d. Bleeding is considered to be completed if the following conditions apply;
   d.1 Turn the steering wheel to lock in both directions 3 to 4 times.
   d.2 Stop the engine with steering wheel in a straight-ahead position and the level of fluid in reservoir does not increase.
e. Start the engine, slowly turn the steering wheel right and left, lightly contacting the wheel stops
f. Check the fluid level, add if necessary
g. Lower the vehicle, set the steering wheel at the straight forward position after turning to the full steer position 2 to 3 times, and stop the engine
h. Again, check the fluid level and refill if required
i. If the fluid is extremely foamy, allow the vehicle to set for a few minutes, then repeat the above procedures.



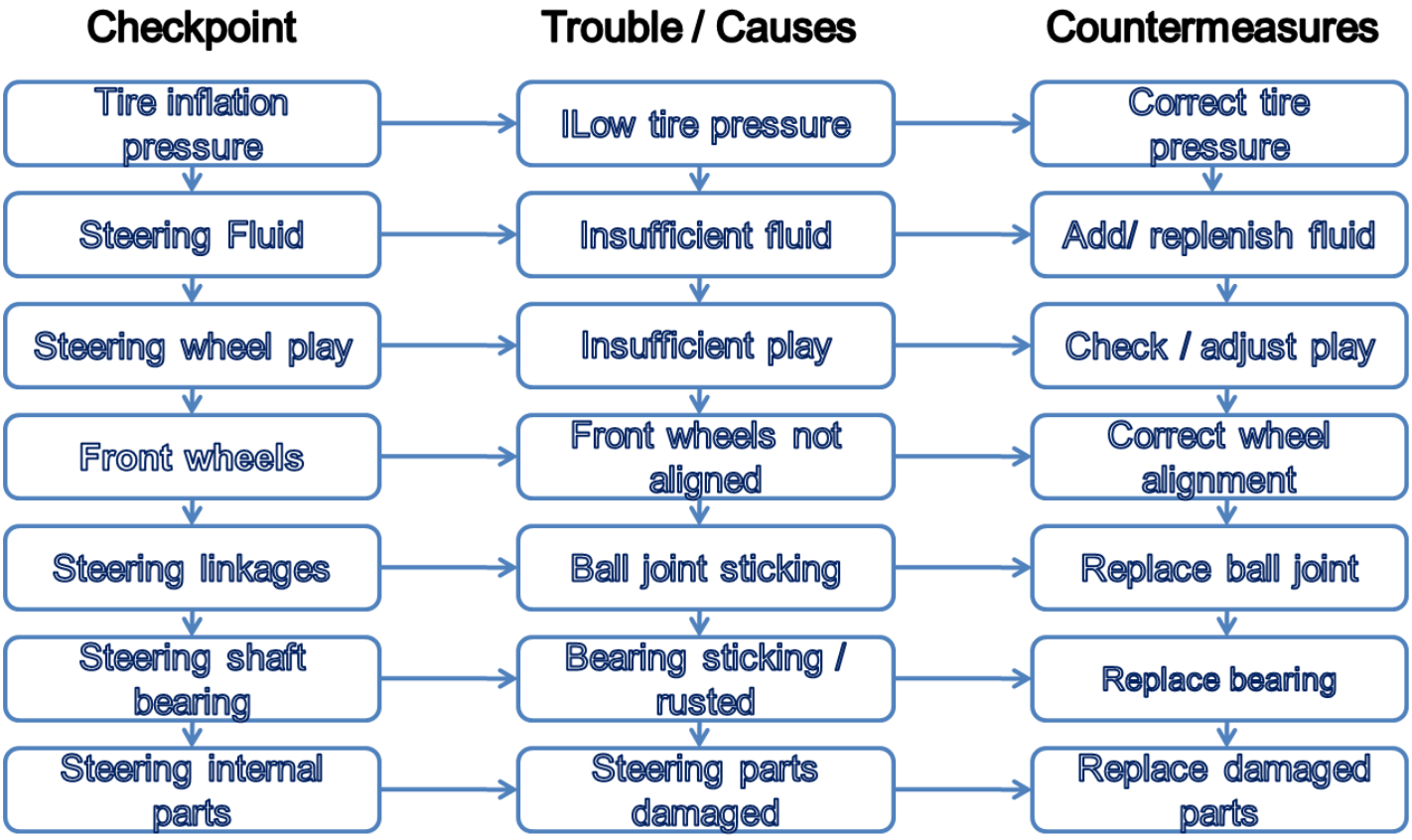

**Warning:**
Do not the let the steering wheel in a lock position for more than 5 seconds, or temperature of fluid will increase rapidly.

Replenish fluid if necessary.

# Steering

## Servicing, Troubleshooting and Maintenance

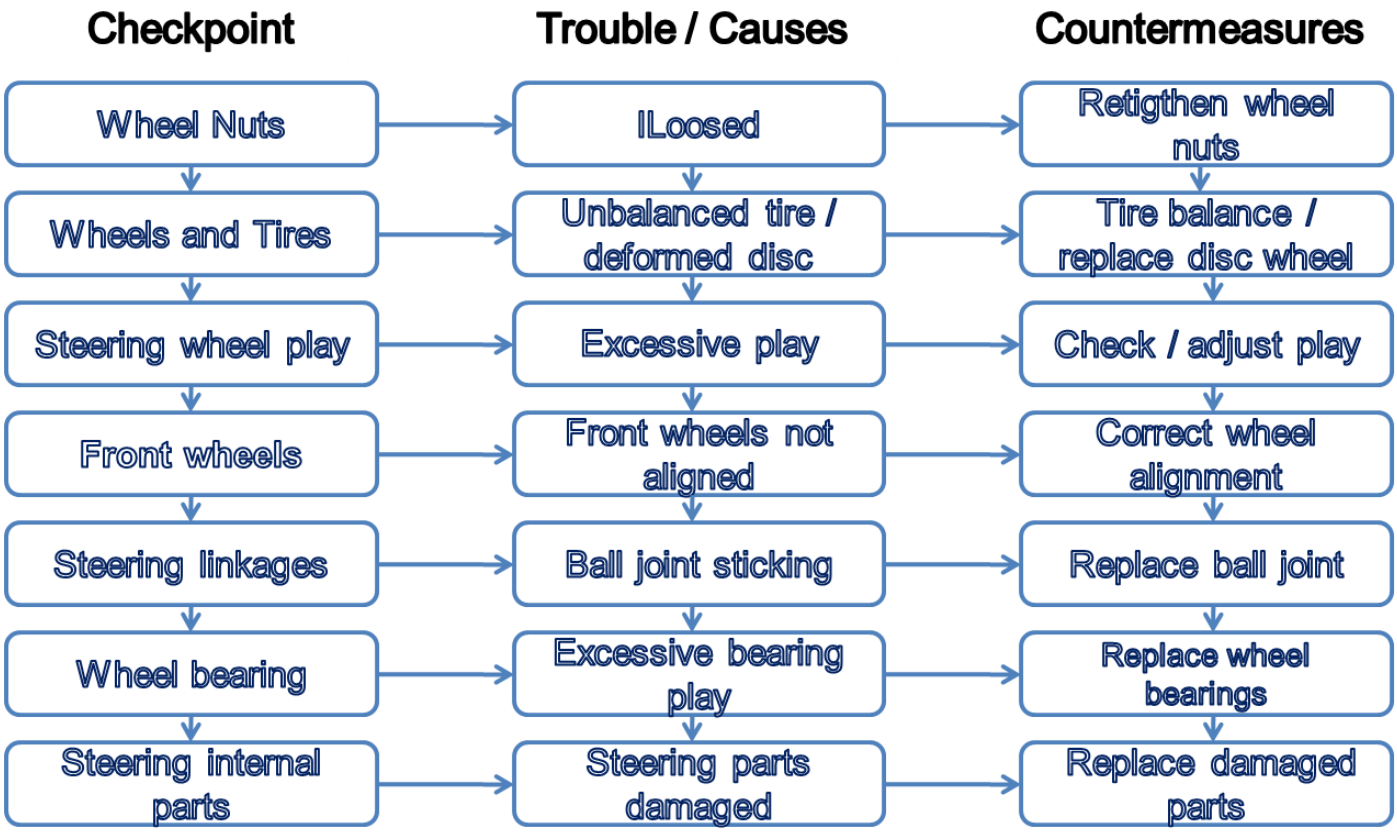
Hard Steering with Poor Steering Wheel Return



# Steering

## Servicing, Troubleshooting and Maintenance

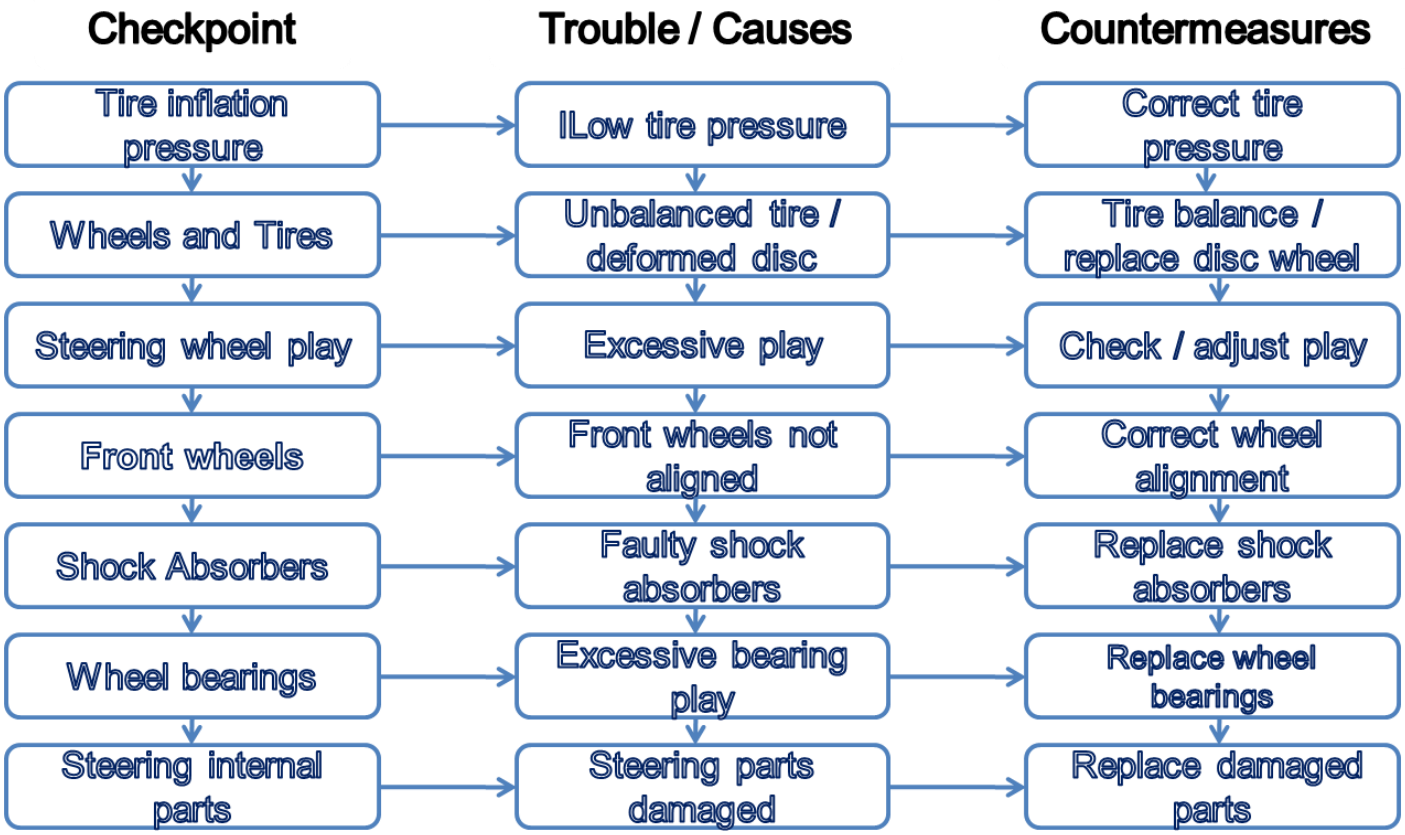
Steering Vibration



# Steering

## Servicing, Troubleshooting and Maintenance

Steering Pulls to One Side



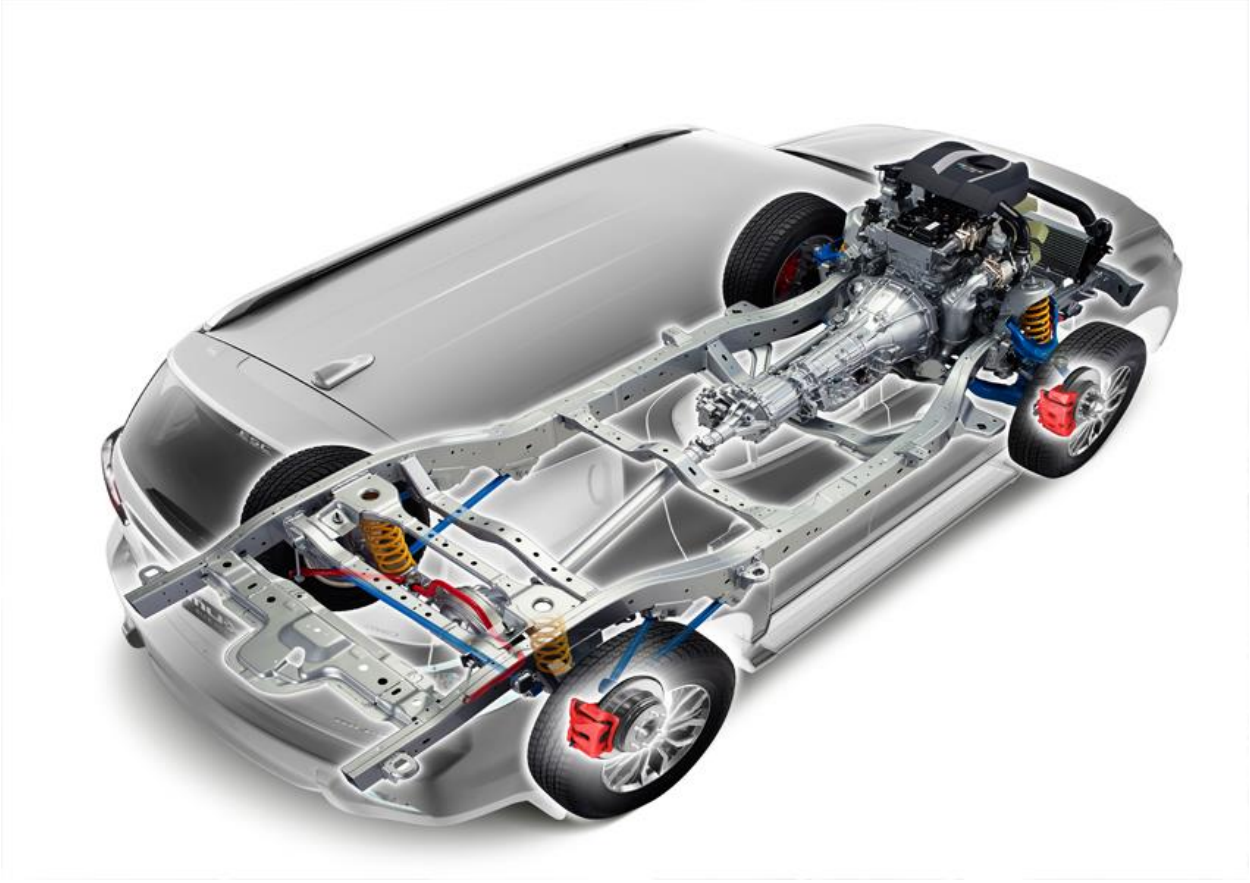
# Steering

## Servicing, Troubleshooting and Maintenance

Steering Wander (Excessive Play)

| Checkpoint | Trouble / Causes | Countermeasures |
|---|---|---|
| Power Steering Unit | IMounting loosed | Correct tire pressure |
| Wheel Alignment | Out of adjustment | Check / adjust wheel alignment |
| Steering wheel and ahsft | Lock nut loosed | Retightened / apply torque |
| Shaft universal joint | Loosed | Retigthened / apply torque |
| Ball Joint | Loosed nuts | Retigthened / apply torque |
| Pitman Arm and Sector Shaft | Loosed | Retigthened / apply torque |
| Steering internal parts | Steering parts damaged | Replace damaged parts |

# Wheels and Tires



# Wheels and Tires

## Introduction

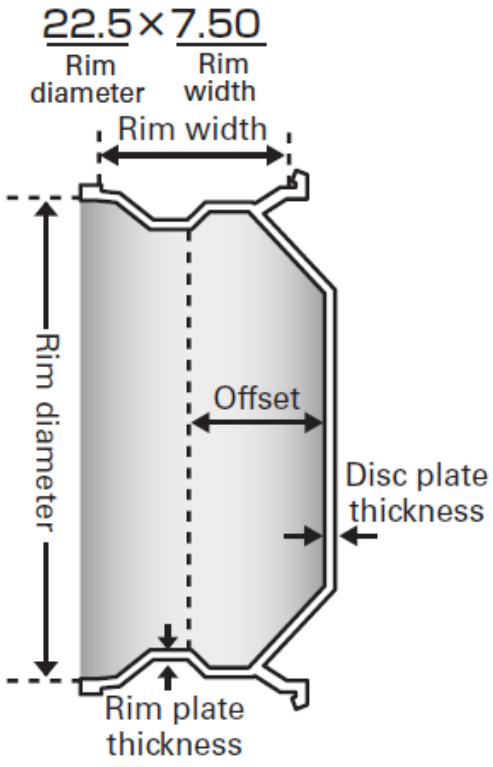
The wheels include the rim to secure the tire and a disc area used to install the wheel to the hub.

Tires are the only ones that come in contact with the road surface and support the three basic efficiencies: Driving, turning and stopping.

# Wheels and Tires

## Wheels

It secures the tires and installs it to the wheel hub. The shape of the mounting of the wheel should meet the various performance and endurance standards depending upon the usage. This includes: Rim diameter, rim width, flange shape and other dimensions.



# Wheels and Tires

## Wheels

Wheel Specification for LCV's

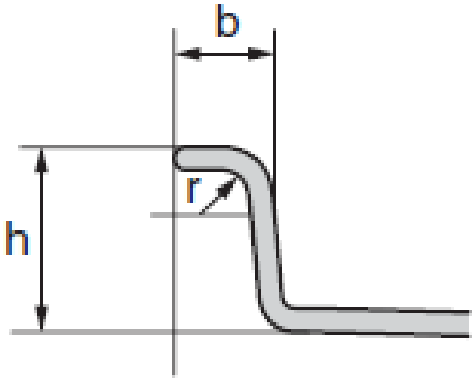
| 51/2 | JJ | x | 13 | 4 | 114.3 | 20 |
|---|---|---|---|---|---|---|
| Rim width (inch) | Flange shape | | Rim diameter (inch) | No. of wheel bolt holes | PCD (mm) | Offset (mm) |

*Flange Shape and Numbering*

It is identified by a letter of the alphabet. The higher the letters, the higher the flange .

Unit: mm (in)

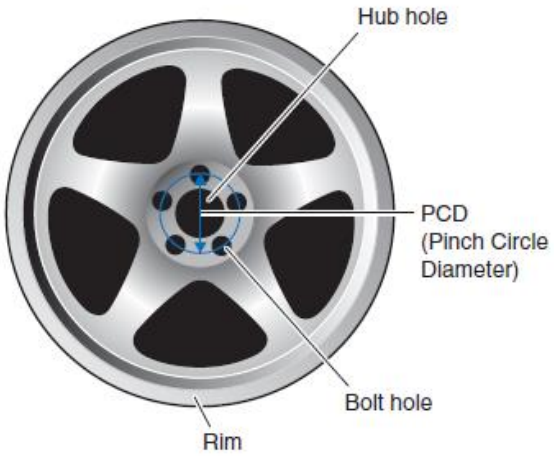
| | h | b | r |
|---|---|---|---|
| B | $14.0^{+1.0}_{-0.5}$ ($0.551^{+0.039}_{-0.020}$) | 10.0 (0.394) | 7.5 (0.295) |
| J | $17.0^{+1.0}_{-0.5}$ ($0.689^{+0.039}_{-0.020}$) | 13.0 (0.512) | 9.0 (0.374) |
| JJ | $18.0^{+0.7}_{-0.7}$ ($0.709^{+0.028}_{-0.028}$) | 13.0 (0.512) | 9.0 (0.354) |
| JK | $18.0^{+1.2}_{-0.0}$ ($0.709^{+0.047}_{-0.000}$) | 13.0 (0.512) | 9.0 (0.354) |
| K | $19.5^{+1.0}_{-0.5}$ ($0.768^{+0.039}_{-0.020}$) | 13.0 (0.512) | 11.0 (0.433) |
| L | $21.5^{+1.5}_{-0.5}$ ($0.846^{+0.059}_{-0.020}$) | 13.5 (0.531) | 12.0 (0.472) |



# Wheels and Tires

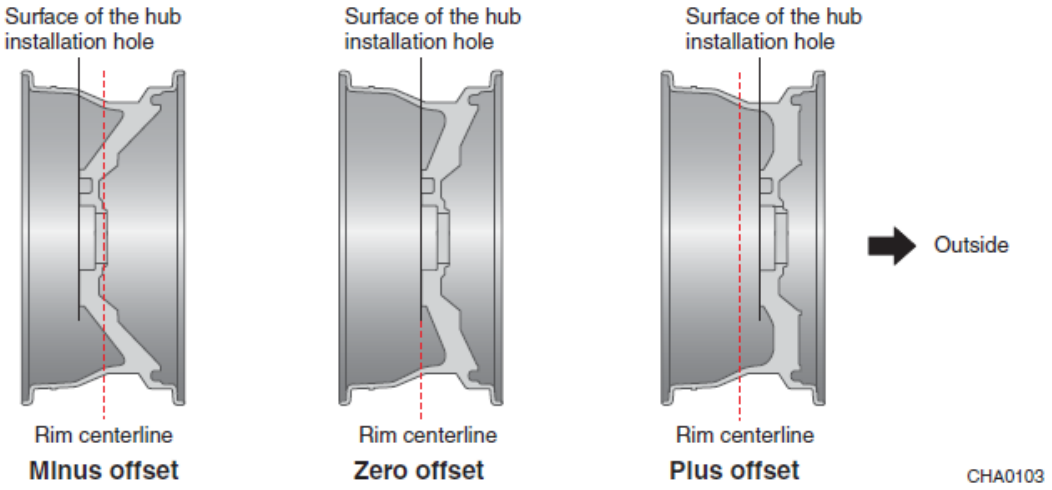
## Wheels

Wheel Specification for LCV's




*Pitch Circle Diameter (PCD)*

It is the diameter of the circle which passes through the center of the all the studs, wheel bolts or wheel rim holes.




*Offset*

Distance between the rim centerline and the surface of the hub installation hole. It prevents interference of brake and wheel alignment.

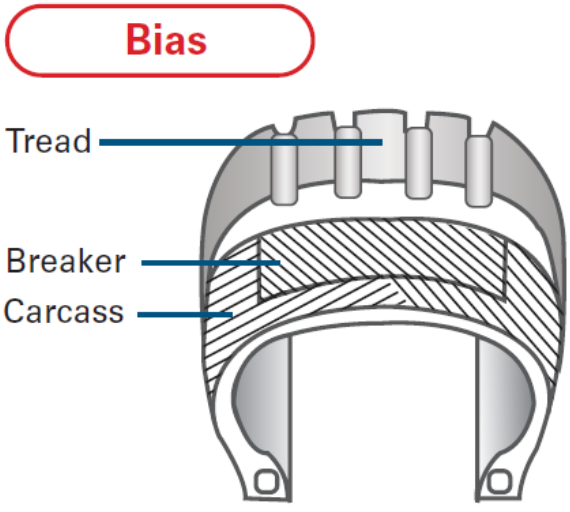
# Wheels and Tires

## Tires

It transfers the power such as driving force, braking force and steering force while it is rotating. The function of a tire can be summarized with the following four roles:

- Support the vehicle weight
- Transfer driving power and braking force to the road surface
- Allow/maintain rolling and directional control of the vehicle.
- Absorb road shock for ride comfort.

Classification and Construction of Tires




**Structure**

Structure in which the cord, such as from the carcass, crosses with the circumferential direction of the tire.

**Merit**

Has flexibility, provides a smooth ride

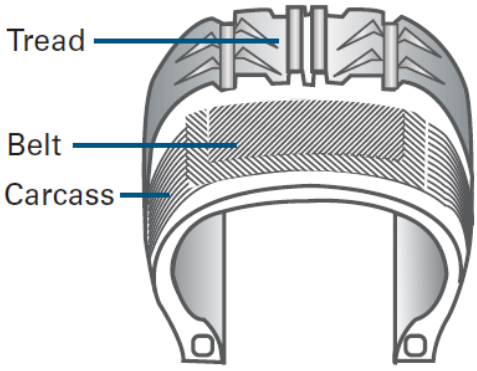
**Demerit**

Compared to the radial, it is inferior in road-hugging properties and abrasion resistance.

# Wheels and Tires

## Tires

**Radial**




**Structure**

Carcass structure intersects at a right angle to the circumferential direction of the tire.

**Merit**

Ground contact area while turning is high, and very good for high-speed performance. Durability is high, so blowouts are minimal, and fuel consumption is good.

**Demerit**

Compared to bias, the ride is less comfortable

*Tubeless Tires*

It contains a special rubber inside the tire which gives better performance in airtightness and makes tubes unnecessary.

Tread Pattern (For CV's)

Rib pattern

Lug pattern

Block pattern

| | Rib pattern | Lug pattern | Block pattern |
|---|---|---|---|
| Structure | Structure with carved grooves parallel to the circumferential direction. | Structure with carved grooves at a right angle to the circumferential direction. | Structure with a rubber block attached to the tread. |
| Suitable driving conditions | The grounding force in the lateral direction is large, and the rolling resistance and noise at high speeds are low. It is widely used as the steering stability is excellent. | Lug pattern excels in driving force and tractive force, and is used for off-road and construction vehicles. It is also suitable for bad and rough roads. | Block pattern has excellent driving force and braking force, though running noise is slightly high. Due to good driving stability and performance in snowy and muddy conditions, it is used for studless, winter tires. |

# Wheels and Tires

## Structure

Tire Specification

*Bias Tire Specification*


**185 / 60 R 14 82 H**

185 : Tire width (mm)

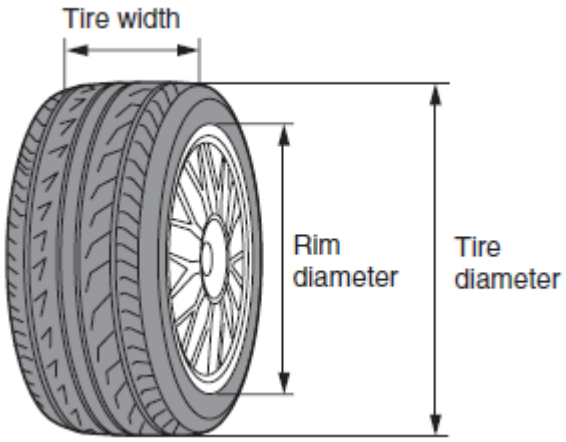
60 : Aspect ratio (%)
Tire height / Tire width x 100

R : Radial Tire

14 : Rim diameter (inch) (1 inch = 25.4 mm)

82 : LI (Load Index)
Load-carrying capacity is the heaviest load that the tire can support. The larger the index, the heavier the load-carrying capacity.

H : Speed symbol (km/h)
Expresses by the speed symbol (code) used in the standards.




| Speed symbol (code) | Speed Km/h (MPH) | Speed symbol (code) | Speed Km/h (MPH) |
|---|---|---|---|
| P | 150 (93) | T | 190 (190) |
| Q | 160 (99) | H | 210 (110) |
| R | 170 (106) | V | 240 (140) |
| S | 180 (112) | Z | Over 240 (over 149) |

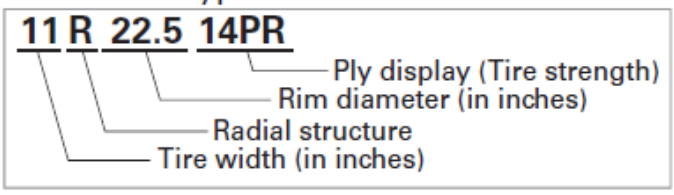
# Wheels and Tires

## Structure

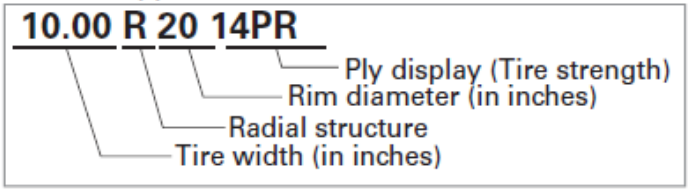
Tire Specification

*Bias Tire Specification*

■ Tubeless type




■ Tube type




### "JIS system" wheel and "ISO system" wheel

The wheels have two systems: JIS system for national standards, and ISO system for international standards. Large vehicles use ISO standards. There are various differences between the systems, such as the number of bolts and the mounting method, but the biggest difference is that an ISO system specifies "Right-hand screw threading for all wheels."

Direction of tightening screws

| | Left side wheel | Right side wheel |
|---|---|---|
| [JIS system] | Left screw | Right screw |
| [ISO system] | Right screw | Right screw |

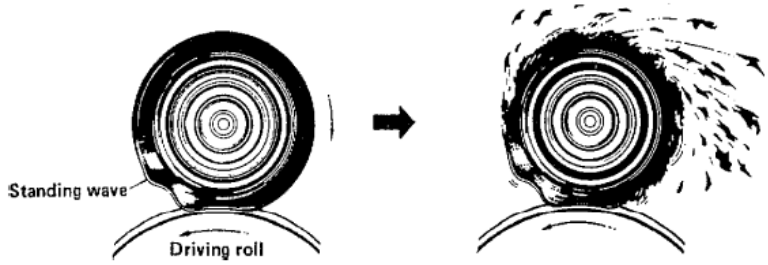
# Wheels and Tires

## Structure

Tire Problems

*Standing Wave*

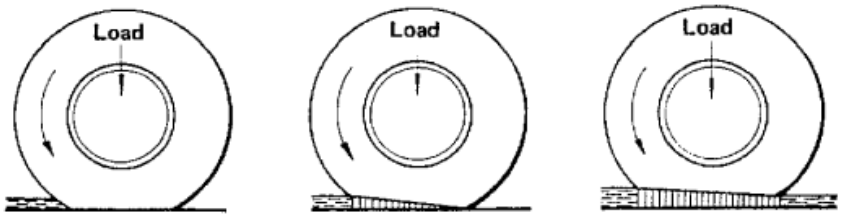
It is a visible wave phenomenon which occurs at vehicle speeds over 150 Km/h (93 MPH). It occurs as excessive tire surface bending until the tires burst.




STANDING WAVE

*Hydroplaning*

It causes the tires to float and slide over the water when driving on a wet road at high speed. It affects vehicle stability and controllability due to ineffective braking, insufficient or no traction ineffective or unreliable steering and side slipping.




Entire contact

Fluid wedge
Water forms a wedge and clings to the tire surface touching the ground.

Hydroplaning
Water forms a wedge causing the tire to become completely detached from the ground.

# Wheels and Tires

## Structure

### Tire Defects

| Tire shape and appearance | | Possible cause (Inspection point) |
|---|---|---|
|  | Tire has abrasive wear creating multiple angles around its circumference. The shoulder has the most obvious signs of abrasive wear. | 1. Tire and/or wheel has poor eccentricity or is bent.<br>2. Hub has poor eccentricity and/or spindle is bent.<br>3. Wheel bearing and/or kingpin excessive play.<br>4. Unbalanced rotating parts. |
|  | Approximately half of the tire shows signs of premature wear. | 1. Unbalanced rotating parts.<br>2. Tire and/or wheel has poor eccentricity or is bent.<br>3. Hub has poor eccentricity and/or spindle is bent.<br>4. Shock absorber is functioning poorly. |
|  | Premature spot wear at one section of tire. | 1. Hard braking or sudden acceleration from a standstill (brake drum eccentricity may be significant).<br>2. Canvas sheet placed inside tire. |
|  | Abrasive wear on one shoulder only. | 1. Poorly adjusted camber or toe-in angle.<br>2. Frequent cornering on sharp curves.<br>3. Rough driving style. |
|  | Abrasive wear on both shoulders. Wear points are diagonally opposed to each other. | 1. Tire and/or wheel has poor eccentricity or is bent.<br>2. Wheel bearing and/or kingpin excessive play. |
|  | Tire crown center groove shows little abrasive wear. Grooves to either side of the center groove show significant premature wear. | 1. Vehicle overload or vehicle operation with insufficient tire air pressure (the opposite situation also frequently occurs when the vehicle is operated with over-inflated tires). |
|  | Lug-type tires. One side of the lug edge shows significant premature abrasive wear. The other edge shows normal wear. | 1. Lug tires mounted on the front of the vehicle may show this type of uneven abrasion due to braking force.<br>2. Lug tires mounted on the rear of the vehicle are exposed to both drive power and braking force. This generally results in more even tire wear. |

# The End