MODULE CONTENT

| Unit of Competency | **DIAGNOSE AND OVERHAUL DIFFERENTIAL** |
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| Module Title | **DIAGNOSING AND OVERHAULING DIFFERENTIAL** |
| Module Descriptor | This unit identifies the competence required to diagnose and overhaul the differential. |
| Nominal Duration | **hours** |
| Summary of the Learning Outcomes: | |
| Upon completion of this module the student must be able to: | |
| LO1. Prepare to diagnose differential assembly | |
| LO2. Diagnose differential assembly | |
| LO3. Disassemble and evaluate differential assembly and components | |
| LO4. Assemble differential assembly and components | |
| LO5. Complete work processes | |

**LEARNING EXPERIENCES**

**LEARNING OUTCOMES NO. 2**

**DIAGNOSE DIFFERENTIAL ASSEMBLY**

| **Learning Activities** | **Special Instructions** |
| --- | --- |
| Read Information Sheet 3.1-1 Diagnose differential assembly | If you have some problem with the content of the information sheet don’t hesitate to approach your Trainer.  If you feel that you are now knowledgeable on the content of the information sheet, you can now answer the self-check provided in the module. |
| Answer Self-Check 3.1-1 on Diagnose differential assembly | Try to answer the Self-check without looking at the Answer Key  Compare your answer to Answer Key 3.1-1 |
| Observe Trainer’s demonstration on Task Sheet 3.1-1 on Diagnose differential assembly | Listen carefully and attentively so that you may be able to perform a task correctly  Ask questions if are in doubt for clarification |
| Perform the Task Sheet 3.1-1 on Diagnose differential assembly | Remember the step-by-step procedure the Diagnose differential assembly |
| Evaluate the performance using the Performance Criteria Checklist 3.1-1 | Repeat the task in case fail to meet the criteria |

**INFORMATION SHEET 1.1-1**

**DIAGNOSE DIFFERENTIAL ASSEMBLY**

**Learning Objectives:**

After reading this **Information Sheet**, you must be able to:

1. Made final inspection.
2. Turned-over vehicle.
3. Restored work area.
4. Managed wastes.
5. Checked and stored tools and equipment.
6. Accomplished workplace documents.

**Diagnose drive shaft and joint (CV Joint)**

Removing the axle from the car After the car is raised and the wheel is begins with the removal of the wheel removed, the hub nut can be unscrewed from cover and wheel hub cover.

The hub nut the axle shaft.

should be loosened before raising the

car and removing the wheel.

The brake line holding clamp must The ball joint must be separated from

be loosened from the suspension. the steering knuckle assembly. To do this,

first remove the ball joint retaining bolt. Then

pry down on the control arm until the joint

is free.

The inboard joint can be pulled free from A special tool is normally needed to

the transaxle. separate the axle shaft from the hub allowing

the axle to be removed from the car.

The axle shaft should be mounted in a Begin boot removal by cutting and

soft-jawed vise for work on the joint. Pieces of discarding the boot clamps.

wood on either side of the axle without

damaging it

Scribe a mark around the axle to Remove the circlip and separate

indicate the boot’s position on shaft. Then, the joint from the shaft.

move the boot off the joint.

Slide the old boot off the shaft. Wipe the axle shaft clean and install

the new boot onto the shaft.

Place the boot into its proper location Using a new circlip, reinstall the joint

on the shaft and install a new clamp. in the shaft. Pack joint grease into the joint and

boot. The entire packet of grease that comes

with a new boot needs to be forced into the

boot and joint.

Pull the boot over the joint and into Install the new large boot clamp and

its proper position. Use a dull screwdriver to reinstall the axle into the car. Torque the hub

lift an edge of the boot up to equalizer the nut after the wheels have been reinstalled and

pressure inside the boot with the outside air. the car is sitting on the ground.

**INFORMATION SHEET 2**

**DIAGNOSE DIFFERENTIAL ASSEMBLY**

**Diagnose drive shaft and joint (Universal Joint)**

A drive shaft must smoothly transfer torque while rotating, changing length, and moving up and down. The different designs of drive shafts all attempt to ensure a vibration-free transfer of the engine’s power from the transmission to the differential. This goal is complicated by the fact that the engine and transmission are bolted solidly to the frame of the car, whereas the differential is mounted to springs. As the rear wheels go over bumps in the road or changes in the road’s surface, the springs compress or expand, changing the angle of the drive shaft between the transmission and the differential, as well as the distance between the two. To allow for these changes, the Hotchkiss-type drive shaft is fitted with one or more U-joints to permit variations in the angle of the drive, and a joint that permits the effective length of the drive shaft to change.

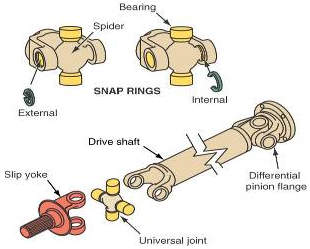
**SHOP TALK**

When a vehicle is intentionally raised or lowered, the length of the drive shaft should be changed

to allow for normal travel of the slip yoke on the

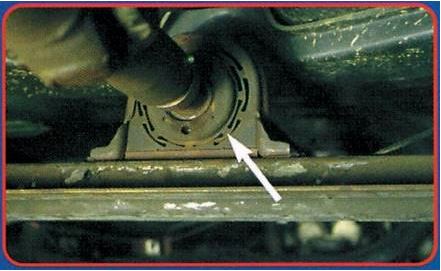
output shaft.

Starting at the front or transmission end of a RWD shaft, there is a slip yoke, universal joint, drive shaft yoke, and drive shaft **(Figure 38-13).** At the rear or differential end, there is another drive shaft yoke and a second universal joint connected to the differential pinion flange.



**Figure 38-13** A drive shaft assembly with exploded U-joints.

In addition to these basic components, some drivetrain systems use a center carrier bearing for added support **(Figure 38-14)**. Large cars with long drive shafts often use a double U-joint, to help minimized driveline vibrations.



**Figure 38-14** A center bearing assembly.

**Slip Yoke**

The most common sliding or **slip yoke (Figure 38-15)** has an internally splined, externally machined bore that lets the yoke rotate at transmission output shaft speed and slide at the same time (hence the name slip yoke). While the need for rotation is obvious, without the linear flexibility, the drive shaft would bend like a bow the first time the suspension jounced.

**Figure 38-15** A typical slip or sliding yoke.

**Drive Shaft and Yokes**

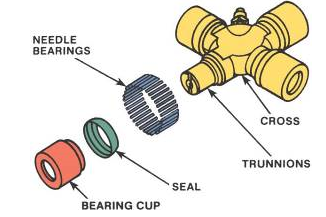
The drive shaft is nothing more than an extension of the transmission output shaft. The drive shaft, which is usually made from seamless steel tubing, transfers engine torque from the transmission to the rear driving axle. The yokes, which are either welded or pressed onto the shaft, provide a means of connecting two or more shafts together. At the present time, a limited number of vehicles are equipped with fibber composite—reinforced fiberglass, graphite, and aluminum- drive shafts. The advantages of using these materials are weight reduction, torsional strength, fatigue resistance, easier and better balancing, and reduced interference from shock loading and torsional problems. Some drive shafts are fitted with a torsional damper to reduce torsional vibrations.

The drive shaft, like any other rigid tube, has a natural vibration frequency. If one end were held tightly, it would vibrate at its own frequency when deflected and released. It reaches its natural frequency at its critical speed. Critical drive shaft speed depends on the diameter of the tube and its length. Diameters are as large as possible and shafts as short as possible to keep the critical speed frequency above the driving speed range. It should be remembered that since the drive shaft generally turns three to four times faster than the tires, proper drive shaft balance is required for vibration-free operation.

**OPERATION OF U-JOINTS**

The U-joint allows two rotating shafts to operate at a slight angle to each other. A French mathematician named Cardan developed the original joint in the sixteenth century. In 1902, Clarence Spicer modified Cardan’s invention for the purpose of transmitting engine torque to an automobile’s rear wheels.

The universal joint is basically a double-hinged joint consisting of two Y-shaped yokes, one on the driving or input shaft and the other on the driven or output shaft, plus across-shaped unit called the cross **(Figure 38-16).**

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**Figure 38-16** A Cardan joint.

A yoke is used to connect the U-joints together. The four arms of the cross are fitted with bearings in the ends of the two shaft yokes. The input shaft’s yoke causes the cross to rotate, and the other trunnions of the cross cause the output shaft to rotate. When the two shafts are at an angle to each other, the bearings allow the yokes to swing around on their trunnions with each revolution. This action allows two shafts, at a slight angle to each other, to rotate together.

Universal joints allow the drive shaft to transmit power to the rear axle through varying angles that are controlled by the travel of the rear suspension. Because power is transmitted on the angle, U-joints do not rotate at a constant velocity, nor are they vibration free.

**Speed Variations (Fluctuations)**

Although simple in appearance, the universal joint is more intricate than it seems because its natural action is to speed up and slow twice in each revolution while operating at an angle. The amount that the speed changes varies according to the steepness of the U-joint’s angle.

U-joint **operating angle** is determined by taking the difference between the transmission installation angle and the drive shaft installation angle. When the universal joint is operating at an angle, the driven yoke speeds up and slows down twice during each drive shaft revolution.

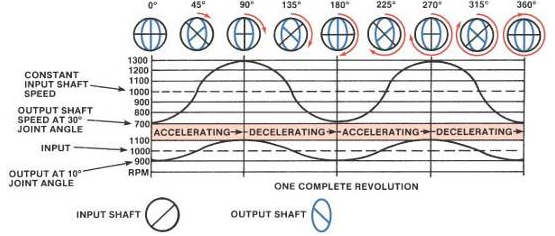
These four speed changes are not normally visible during rotation. But they may be understood more easily after examining the action the action of a U-joint. A universal joint is a coupling between two shafts not in direct alignment, usually with changing relative positions. It would be logical to assume that the entire unit simply rotates. This is true only for the universal joint’s input yoke.

The output yoke’s circular path looks like an ellipse because it can be viewed at an angle instead of straight on. This effect can be obtained when a coin is rotated by the fingers. The height of the coin stays the same even though the sides seem to get closer together.

This illusion might seem to be a merely visual effect, but is more than that. The U-joint rigidly locks the circular action of the input yoke to the elliptical action of the output yoke. The result is similar to what would happen when changing a clock face from a circle to an ellipse.

Like the hands of a clock, the input yoke turns at a constant speed in its true circular path. The output yoke, operating at an angle to the other yoke, completes its path in the same amount of time. However, its speed varies, or is not constant, compared to the input.

Speed fluctuation is more easily visualized when looking at the travel of the yokes by 90-degree quadrants **(Figure 38-17)**. The input yoke rotates at a steady or constant speed through the complete 360-degree turn. The output yoke quadrants alternate between shorter and longer distance travel than the input yoke quadrants. When one point of the output yoke covers the shorter distance in the same amount of time, it must travel at a slower rate. Conversely, when travelling the longer distance (but only 90 degrees) in the same amount of time, It must move faster.



**Figure 38-17**  A graph showing typical drive shaft yoke speed fluctuations.

Because the average speed of the output yoke through the four-90 degree quadrants (360 degrees) equals the constant speed of the input yoke during the same revolution, it is possible for the two mating yokes to travel at different speeds. The output yoke is falling behind and catching up constantly. The resulting acceleration and deceleration produces a fluctuating torque and torsional vibrations characteristic of all Cardan U-joints. The steeper the U-joint angle, the greater the fluctuations in speed will be. Conversely, the smaller the angle, the speed will change less.

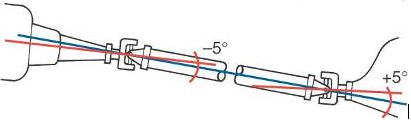
**Phasing of Universal Joints**

The torsional vibrations set up by the fluctuations in velocity are transferred down the drive shaft to the next U-joint. At this joint similar speed fluctuation occurs. Since these speed variations take place at equal and opposite angles to the first joint, they cancel out each other. To provide for this cancelling effect, drive shafts should have at least two U-joints and their operating angles must be equal to each other. Speed fluctuations can be cancelled if the driven yoke has the same point of rotation, or same plane, as the driving yoke. When the yokes are in the same plane, the joints are said to be “in phase.”

On a two-piece drive shaft, you may encounter problems if you are not careful. The center U-joint must be disassembled to replace the center support bearing. The center driving yoke is splined to the front drive shaft. If the yoke’s position on the drive shaft is not indicated in some manner, the yoke could be installed in a position that is out of phase. Manufacturers use different methods of indexing the yoke to the shaft. Some use aligning arrows. Others machine a master spline that is wider than the others. The yoke and shaft cannot be reassembled until the master spline is aligned properly. When there are no indexing marks, you should index the yoke to the drive shaft before dissembling the U-joint. This saves time and frustration during reassembly.

**Cancelling Angles**

Vibrations can be reduced by using cancelling angles **(Figure 38-18).** Carefully examine the illustration, and note that the operating angle at the front of the drive shaft is offset by the one at the rear drive shaft. When the front universal joint accelerates, causing a vibration, the rear universal joint decelerates, causing a vibration. The vibrations created by the two joints oppose and dampen the vibrations from one to the other. The use of cancelling angles provides a smoother drive shaft operation.



**Figure 38-18** When a drive shaft’s joints are in phase and have cancelling angles, inherent vibrations are reduced.

**TYPES OF U-JOINTS**

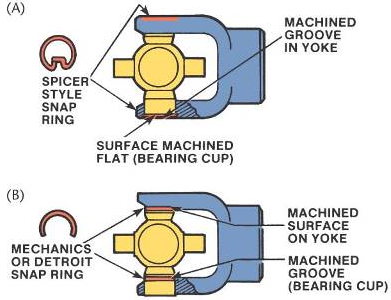
There are common designs of U-joints: single U-joints retained by either an inside or outside snap ring, coupled U-joints, and U-joints held in the yoke by U-bolts or lock plates.

**Single Universal Joints**

The single Cardan/Spicer universal joint is also known as the cross or four-point joint. These two names aptly describe the single Cardan, since the joint itself forms a cross, with four machined trunnions or points equally spaced around the center of the axis. Needle bearings used to abate friction and provide smoother operation are set in bearing cups. The trunnions of the cross fit into the cup assemblies and the cup assemblies fit snugly into the driving and driven universal joint yokes. U-joint movement takes place between the trunnions, needle bearings, and bearing cups. There should be no movement between the bearing cup and its bore in the universal joint yoke. The bearings are normally held in place by snap rings that drop into grooves in the yoke’s bearing bores. The bearing caps allow free movement between the trunnion and yoke. The needle bearing caps may also be pressed into the yokes, bolted to the yokes, or held in place with U-bolts or metal straps.

There are other styles of single U-joints. The method used to retain the bearing caps is the major difference between these designs. The Spicer style **(Figure 38-19A)** uses an outside snap ring that fits into a groove machined in the outer end of the yoke. The bearing cups for this style are machined to accommodate the snap ring.

The Mechanics or Detroit/Saginaw style **(Figure 38-19B)** uses an inside snap ring or C-clip that fits into a groove machined in the bearing cup on the side closer to the grease seal. When installed, the clip rests against the machined inside portion of the yoke. The snap rings are retained by nylon injected into the retaining ring grooves.

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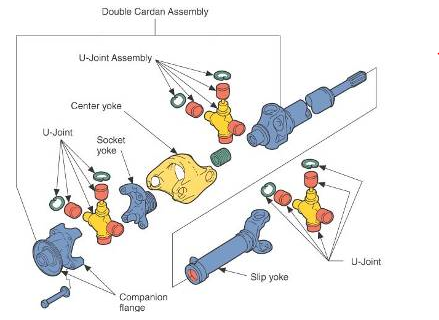
**Figure 38-19 (A)**  A Spicer-style U-joint and **(B)** a mechanics or Detroit-style U-joint.

The Cleveland style is an attempt to combine different joint style to have more applications from one joint. The bearing cups for this U-joint are machined to accommodate either Spicer or Mechanics style snap rings. If a replacement U-joint comes with both style clips, use the clips that pertain to your application.

**Double- Cardan Universal Joint**

A **double-Cardan** U-joint is used with split drives shafts and consists of two Cardan universal joint closely connected by a centering ball socket and a center yoke, which functions as a ball-and-socket .The ball-and socket splits the angle of the two shafts between two U-joints **(Figure 38-20).** Because of the centering socket yoke, the total operating angle is divided equally between the two joints. Since the two joints operate at the same angle, the normal fluctuations that result from the use of a single U-joint are cancelled out. The acceleration and deceleration of one joint is cancelled by the equal and opposite action of the other.

The double-Cardan joint is classified as a constant velocity universal joint. It is most often found in front-engine RWD luxury-type vehicles.

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**Figure 38-20**  A double Cardan joint.

**DIAGNOSIS OF DRIVE-SHAFT**

**AND U-JOINT PROBLEMS**

A failed U-joint or damaged drive shaft can exhibit a variety of symptoms. A clunk that is heard when the transmission is shifted into gear is the most obvious. You can also encounter unusual noise, roughness, or vibration.

To help differentiate a potential drivetrain problem from other common sources of noise or vibration, it is important to note the speed and driving condition at which the problems occurs. As a general guide, a worn U-joint is most noticeable during acceleration or deceleration and is less speed sensitive than an unbalanced tire (commonly occurring in the 30 to 60 mph[50 to 100 km/h]range) or a bad wheel bearing(more noticeable at higher speeds). Unfortunately, it is often very difficult to accurately pinpoint drivetrain problems with only a road test. Therefore, expand the undercar investigation by putting the vehicle up on the lift, where it is possible by get a good view of what is going on underneath.

The first problem most likely encountered is an undercar fluid leak. If a lot of lube is escaping from the pinion shaft seal, the drivetrain noise could be caused by a bad pinion bearing. To confirm the problem, start the engine, put the transmission on the gear, and listen at the carrier. If the bearing is noisy, it is necessary to make one of those difficult judgment calls. If the bearing sounds fine but the pinion seal is still leaking, suggest an on-the-car seal replacement.

On some vehicles, seal replacement is a simple procedure that involves removing the pinion flange and replacing the seal. However, always refer to the service manual for the correct procedure and note any special precautions to be taken.

At the other end of the driveline, inspect the transmission’s extension housing seal the same way. If it is leaking, the seal itself can be easily replaced. Check the extension housing bushing. That is the most likely reason the seal went bad in the first place. Once the yoke is remove, an internal expanding bearing/bushing puller makes short work of bushing replacement. Before pushing the slip yoke back in after the new seal is installed, make sure the machined surface of the bore is free of scratches, nicks, and grooves that could damage the seal. For that added margin of safety, a little transmission lube or petroleum jelly on the lip of the seal helps the parts slide in easily.

If the seals pass the test, continue driveline examination by inspecting the U-joint grease seals for signs of rust, leakage, or lubrication breakdown. Also, check for excessive joint movement by firmly grasping and attempting to rotate the coupling yoke back and forth in opposite directions. If any perceptible trunnion-to bearing movement is felt, the joint should be replaced.

The runout of the drive shaft should also be checked. If there is excessive runout, determine the cause and make the necessary repairs. If the runout is fine, check the phasing of the joints and their angle. To check their operating angle, use an inclinometer. This instrument, when attached to the drive shaft, displays the angle of the drive shaft along anypoint. Your finding from this test should be compared to specifications. Normally, if the angles are wrong, the rear axle has moved in its mounting.

As a final diagnosis inspection point, check the entire length of the drive shaft for excess undercoating, dents, missing weights, or other damage that could cause an imbalance result in a vibration. If no damage is found, the drive shaft should be removed and its balance checked by a specialty shop.

When a U-joint is damaged or excessively worn, it must be replaced. Photo Sequence 38 covers the typical procedure for removing a U-joint from a drive shaft. After a replacement joint is obtained, it needs to be installed. Photo Sequence 39 covers the assembly of a common U-joint.

**INFORMATION SHEET 3**

**DIAGNOSE DIFFERENTIAL ASSEMBLY**

**Diagnose drive shaft and joint (Universal Joint)**

Clamp the slip yoke in a vise and support Remove the rings on the tops of the

the outer end of the drive shaft. bearing cups. Make index marks in the yoke so

that the joint can be assembled with the correct

phasing.

Select a socket that has an inside Select a second socket that can slide

diameter large enough for the bearing cup to into the shaft’s bearing cup bore-usually a 9/16

fit into; usually a 1-1/4 inch socket works. inch socket.

** **

Place the large socket against Position the others socket to the center

one vise jaw. Position the drive shaft of the bearing cup opposite to the one in line

yoke so that the socket is around a with the large socket.

bearing cup.

** **

Carefully tighten the vise to press the Separate the joint by turning the shaft

bearing cup out of the yoke and into the large over in the vise and driving the spider and

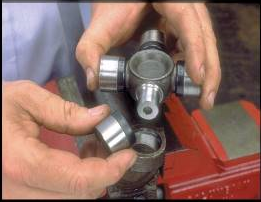
socket. remaining bearing cup down through the yoke

with a brass drift and hammer.



Use a drift and hammer to drive the

joint out of the other yokes

Clean any dirt from the yoke and the Carefully remove the bearing cups

retaining ring grooves. from the new U-joint.

Place the new spider inside the yoke and Start one cup into the yoke’s ear

push it to one side. and over the spider’s trunnion.

Carefully place the assembly in a vise and Remove the shaft from the vise and push

press the cup partially through the ear. the spider toward the other side of the yoke.

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Start a cup into the yoke’s ear and over Place the shaft in the vise and tighten

the trunnion the jaws to press the bearing cup into the ears

and over the trunnion. Then install the snap

rings. Make sure they are seated in their

grooves



Position the joint’s spider in the drive shaft y

yoke and install the two remaining bearing cups.