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**STUDENT OUTLINE**

DESIGN CHARACTERISTICS AND PRINCIPLES
OF OPERATION OF AUTOMOTIVE COMPONENTS

**LEARNING OBJECTIVES:** Learning objectives are not specified; however, function and basic principles of operation of engines and their subsystems will be covered. Instruction, at the familiarization level, is also provided on automotive power transmission, brake, steering, and suspension systems.

**OUTLINE**

**1. INTRODUCTION TO AUTOMOTIVE COMPONENTS**

a. It's important that all students have a basic under- standing of the complete power transmission system before we get into each of the individual components.

b. Power Flow

(1) The frame supports the engine, wheels, body and power train members. It is made of steel, carefully shaped and then welded or riveted together. Cross members reinforce the frame and also support the engine, transmission, transfer, and wheels. The frame is extremely rigid and strong so it can withstand the shocks, twists, vibrations, and other strains created by on and off road driving conditions.

(2) The automotive engine is an internal combustion engine that creates a twisting force known as torque. This torque is applied to shafts and gears in various components between the engine, rear wheels, and front wheels when the vehicle is operated in all-wheel drive.

(3) Tactical wheeled vehicles that employ manual transmissions use a clutch to connect and disconnect the flow of power from the engine to the transmission. It is necessary to interrupt the flow of power to shift gears. Some of our vehicles are equipped with automatic trans- missions that do not

use a clutch. A device called a torque converter serves essentially the same purpose as a clutch on vehicles with automatic transmissions.

(4) A transmission is installed behind the clutch and allows the operator to change vehicle speed by means of different gear ratios. If the transmission is a manual transmission, the various speeds of the transmission are selected manually by moving a gear shift lever. As I stated earlier, some of our vehicles employ automatic transmissions that do the job of shifting gears with only minimal assistance from the operator.

(5) Transfer assemblies are used in our tactical wheeled vehicles to divide engine torque between the front and rear driving axles. The transfer assembly allows the front axle to be engaged or disengaged by the operator by shifting a lever mounted in the cab of the vehicle.

(6) A drive shaft, sometimes referred to as a propeller shaft, is connected to the transmission and transfer and carries the power to the driving wheels. Universal joint is fastened to each end of the drive shaft. The universal joints allow the driving axles to move up and down without bending or breaking the drive shaft. The drive shaft can continue turning even though both ends are not on the same plane. A slip joint is splined to the universal joint on the front end of the propeller shaft that allows for the shortening and lengthening of the propeller shaft that occurs when the axles move up and down.

(7) When a vehicle turns a corner, the outside wheel has to travel farther than the inside wheel, which means that it has to turn faster. A mechanical device known as a differential is used to permit unequal speeds and still provide power to both wheels while the vehicle is negotiating a turn. The rear axle assembly is made complete by having two axle shafts. These shafts are connected to gears within the differential and the outer ends are connected to hubs of the wheels, so that each shaft and wheel turns as an independent unit.

(8) I have just described the flow of power in a typical tactical wheeled vehicle. The power originates in the engine and finally reaches the rear wheels after passing through the various components I have described.

c. It has been determined that it's important for an organizational level mechanic to know about the principles of operation and construction of the internal combustion engine even though, as 3521's, you are not authorized to go inside the engine for repair. To provide you with that knowledge, we will use a single cylinder Briggs and Stratton engine. It has essentially all of the components that a multi-cylinder engine has, but it is infinitely easier to work with. As you disassemble and assemble the engine, keep in mind that we are only teaching basic principles of operation and construction of a

representative internal combustion engine. Considering what I have just said, and using the tools on your workbench, we'll begin disassembly and see what goes on inside this little engine you have in front of you.

(1) We'll start with the cylinder head. As you can see, the cylinder head is connected to the cylinder block with head bolts. In order to see how the head is made and learn its purpose, we'll remove it and take a good look. Go ahead and remove the head bolts now.

(a) Look at the inside of the head, notice that it's concave. This space serves as a combustion chamber for the fuel and air mixture.

(b) If this was a six-cylinder engine and the head was cast in one piece, there would be six combustion chambers.

(c) Look at the outside of the head; the threaded hole houses a spark plug. If this was a diesel engine, it would contain an injector or fuel nozzle. We'll talk about injectors and nozzles later.

(d) To prevent compression leakage, a gasket is placed between the cylinder head and engine block. This particular engine is air cooled; however, if it was a liquid cooled engine, the gasket would also prevent coolant from entering the cylinder.

(2) Look now at the top of the cylinder block. These two things I am pointing to are the valves. We'll talk about them in a minute. Right now I want you to know that some engines have the valves in the head and some have them in the block, as this engine does.

(3) Now, let's remove the oil pan and look inside of our engines. Remove the oil pan bolts at this time.

(a) Notice the two gears and the timing marks on them. This small gear on the left is the crankshaft gear; the other is the camshaft gear. Remove the crankshaft and camshaft gears.

(b) As you can see, the camshaft gear is attached to the camshaft. Examine the camshaft and take note of the offsets; these are called cams, one for each valve.

(c) The high point of the cam is called the lobe or toe and the lowest part is called the base circle or the heel. The camshaft is mounted in the engine block so the cams are directly under the valve followers.

(d) When the camshaft turns, the lobe will push on the valve follower, forcing the valve up, compressing the valve spring and opening the valve.

(e) As the camshaft continues to rotate, the lobe moves past the valve follower, and the spring forces the valve to close. We now have a way to open and close the valves, allowing fresh air to enter and exhaust gases to leave the engine. But how is the camshaft turned?

(f) Remember the crankshaft gear? It fits on the crankshaft and is meshed with the camshaft gear. When the crankshaft turns, the camshaft will also turn.

(4) By removing two bolts securing the rod cap to the connecting rod, we can remove the piston. Remove the two bolts now.

(a) Push upward on the connecting rod until the piston clears the cylinder. Look inside the engine and notice how the crankshaft is shaped; this is important.

(b) Now, examine the piston. The top of the piston receives force from the combustion of the fuel and air mixture that occurred in the combustion chamber of the head.

(c) As the piston is pushed downward by the force of the combustion, the connecting rod will cause the crankshaft to turn.

(d) Without removing them, look at the piston rings. The rings seal the cylinder, so we get the full effect of the combustion applied to the top of the piston, rather than having it blow by the piston and be wasted.

d. Engine Assembly

(1) First, position the piston in the ring compressor and tighten the adjusting screw. Place the connecting rod in the cylinder, until the ring compressor contacts the engine block.

(2) Now, tap the top of the piston lightly with the handle of a hammer, until the piston is in the cylinder and remove the ring compressor.

(3) Next, place the connecting rod on the crankshaft journal and install the rod cap and oil dipper.

(4) Now, install the valve followers and the camshaft, and align the crankshaft and camshaft timing gear marks.

(5) Next, install the side plate and gasket.

e. The term 4-stroke cycle refers to the number of times the piston moves up and down between power strokes. The 4-strokes are called intake,

compression, power, and exhaust. We will discuss them in the order they were just named. Before we do, let's define some common terms that will be used.

(1) The piston has to be moved in the cylinder by some outer force to get it started. This is called cranking and is accomplished in different ways. For example, to crank the engine you are working on, a rope has been wrapped around a pulley which spins the crankshaft. Multi-cylinder engines are cranked by an electric starter motor that turns the flywheel.

(2) When you hear someone say the letters TDC or BDC, they are talking about the position of the piston in the cylinder. TDC is just a short way of saying "Top Dead Center" and BDC is saying "Bottom Dead Center." At TDC, the crankshaft throw is pointed straight up and the piston is at the highest point of travel in the cylinder. The crankshaft and piston are just opposite of this at BDC.

f. As the crankshaft is rotated by cranking, the piston is moved to TDC to start the intake stroke. At this time, the camshaft gear turns so the cam lobe under the intake valve is beginning to open the intake valve.

(1) As the rotating crankshaft pulls the piston down, it draws the fuel/air mixture of a gasoline engine past the open intake valve into the combustion chamber. If this was a diesel engine, only air would be entering the cylinder at this time.

(2) When the piston reaches BDC, the intake stroke ends. The cam lobe has moved from under the follower, allowing it to rest on the base circle of the cam.

(3) The valve spring now closes the intake valve and seals the fuel/air mixture in the combustion chamber.

(4) Continued cranking causes the piston to be moved upward. The air is compressed as the piston gets close to the cylinder head because the valves are closed and the area above the piston head is essentially sealed off. This is the compression stroke.

(5) As the piston finishes the compression stroke, the power stroke begins with an electrical spark igniting the fuel/air mixture of a gasoline engine or fuel being injected in a diesel engine. In a diesel engine the compression ratio is so high that the air is hot enough to ignite the fuel when it is injected into the engine.

(a) This causes a high pressure in the cylinder that drives down on the piston head with great force.

(b) The downward force on the piston is transmitted through the connecting rod to the crankshaft throw. The result is a powerful twist on the crankshaft which gives it a spin. Thanks to the heavy flywheel, the crankshaft now continues to turn through the nonpower strokes without cranking by other means.

(6) When the piston reaches BDC, the power stroke ends and the exhaust stroke begins.

(a) The timing gears have turned the camshaft far enough so the cam lobe under the exhaust valve contacts the follower and opens the exhaust valve. The rotating crankshaft moves the piston up, pushing burned gases out of the cylinder past the exhaust valve.

(b) By the time the rising piston reaches TDC, the camshaft has turned far enough to allow the exhaust valve to close. At this time, the intake valve cam lobe has moved into position to open the intake valve. This has the piston and valves in the proper position to begin another intake stroke and to repeat all four strokes again.

g. You remember that a four-cycle engine needs four full strokes of the piston to go through one cycle: intake, compression, power, and exhaust. Since there were two strokes for each complete revolution of the crankshaft, it took two revolutions to complete a cycle. Thus, there was only one power stroke for every two revolutions.

(1) The idea of a two-cycle engine is to complete the cycle in only two strokes of the piston, that is, in only one revolution of the crankshaft. Thus, a two-cycle running at the same revolutions per minute (rpm) as a four-cycle engine will have twice as many power strokes.

(2) Two-stroke cycle diesel engines do not have intake valves; they do employ exhaust valves. Air is delivered to the cylinder through a series of intake ports in the cylinder wall. To ensure a sufficient amount of air for engine operation, an air pump or blower is used. A blower is a mechanical device mounted to the engine, and is used to deliver a large volume of air to the engine at high pressure.

h. The operation of a two-stroke engine is as follows: remember, one cylinder will fire for each revolution of the crankshaft.

(1) With the piston at the bottom of its stroke, the intake ports previously mentioned will be open and the exhaust valve(s) will also be open.

(2) Air is being pushed into the engine by the blower and this air is also pushing the burned gases from the previous cycle out, while filling the cylinder with fresh air.

(3) As the piston starts its upward travel, the exhaust valve or valves will close and the intake ports will be covered by the piston.

(4) At this time, all exhaust gases have been blown out and the cylinder is full of fresh air.

(5) The rest of the upward stroke is an ordinary compression stroke that you are familiar with. Just before the piston reaches TDC, fuel is introduced into the compressed air and combustion occurs, sending the piston down on its power stroke.

(6) As the piston moves down the cylinder, the exhaust valve(s) will begin to open, the intake ports will be uncovered, and the cycle will repeat itself.

i. Final Assembly and Operation. Position the head gasket on the head and align the bolt holes. Insert the head bolts and alternate the tightening sequence to ensure the head gasket is properly seated and to prevent warpage of the head. Tighten to a snug fit with the ratchet and socket, then torque each head bolt to 98 inch pound.

## 2. DIESEL ENGINE FUEL SYSTEMS

a. Functions of the Fuel Delivery System

(1) There are seven basic functions that must be accomplished by the fuel delivery system.

(a) Drawing fuel from the tank in sufficient quantity to supply the engine under all operating conditions.

(b) Pressurizing fuel sufficiently to ensure proper delivery to the combustion chambers.

(c) Distribution of metered fuel to the correct cylinder.

(d) Timing the moment of injection.

(e) Metering fuel according to engine power requirements.

(f) Atomization of fuel.

(g) Direction of metered fuel into the combustion chambers.

(2) These seven functions are accomplished by components of the fuel system.

b. Fuel System Components

(1) The fuel tank, in addition to storing fuel for the engine, provides a mounting base for the filler neck, fuel strainer, drain plug, fuel lines, and the fuel sending unit.

(2) Fuel lines carry the diesel fuel along predetermined routes to components of the fuel system.

(3) A mechanical, lift-type pump draws diesel fuel from the tank and provides a full block of fuel in the fuel lines.

(4) Filters are used in the fuel system to trap and prevent impurities from damaging fuel system components.

c. Distributor Type Diesel Fuel Injection System

(1) The distributor type injection system uses a mechanical lift pump to draw fuel from the tank.

(2) When fuel enters the mechanical pump, it is forced under low pressure to the fuel filter where any impurities in the fuel are trapped.

(3) From the fuel filter, the fuel, still under low pressure, is forced to an injection pump.

(a) The injection pump raises the fuel to the correct injection pressure, meters quantity of fuel, and times the injection.

(b) Fuel is forced out of the injection pump when the discharge port of the rotor lines up with one of the discharge outlets inside the pump. As the rotor turns, its single port discharges a pulse of fuel into each of the hydraulic head outlets in sequence.

(4) Diesel fuel, now under high pressure, is routed through individual lines to fuel nozzles located at each cylinder. Fuel nozzles direct fuel into the precombustion chambers. Fuel nozzles do not meter or pressurize the diesel fuel.

(5) Fuel enters individual nozzles at a rate and amount that varies with demands of the engine. When the engine fuel demand is low, such as at idle, fuel pulses are smaller and farther apart than when the engine is running at wide open throttle. At wide open throttle, larger amounts of

fuel, spaced closely together, force the nozzles to open more often and to stay open longer to meet the needs of a high speed engine.

d. Pressure-Timed Diesel Fuel Injection System.

(1) In the pressure-timed diesel fuel injection system, fuel is supplied from the tank to the pressure-timed gear (PTG) pump through a delivery line.

(2) An in-line filter is placed in the fuel inlet line between the tank and pump to filter foreign matter and moisture.

(3) A return line from the PTG pump to the fuel tank is provided to bleed off any excess fuel so the operating pressure can be regulated.

(4) The PTG pump delivers controlled amounts of fuel to pressure-timed injectors.

(5) A return line connects the injectors to the fuel tank to the pressurize-timed injectors.

(6) A mechanical governor controls the flow of fuel from the gear pump, as well as the maximum and idle speeds.

(7) Fuel leaving the pump flows through a shutdown valve, inlet supply lines, and into the injectors.

(8) An injector is provided at each engine cylinder to spray fuel into the combustion chambers. Injectors deliver equal amounts of fuel to ensure atomization and control the start rate, and duration of injection.

## 3. ENGINE LUBRICATION AND COOLING SYSTEMS

a. Engine Lubrication

(1) Excessive friction in the engine would mean rapid destruction. We cannot eliminate friction, but we can reduce it by use of friction reducing lubricants. Engine lubricating oils have four functions:

(a) to prevent metal-to-metal contact in moving parts,

(b) assist in carrying heat away from the engine,

(c) to clean engine parts, and

(d) form a seal between piston rings and cylinder walls to prevent blowby of combustion gases.

(2) To remove impurities from the engine lubrication system, an oil filter is mounted outside of the engine and connected so all of the oil passes through it each time oil is circulated through the engine.

(3) An oil temperature regulator and cooler is used to prevent oil temperature from rising too high in hot weather and assist in raising the temperature of the oil during initial engine warm-up.

(4) All military tactical wheeled vehicles use a positive crankcase ventilating system. This system is part of the emission control system which reduces air pollution. The air from the engine crankcase containing blowby gases, fuel and water vapors is drawn through the intake manifold to the combustion chamber. There, the combustion gases are burned and discharged out through the exhaust system.

b. Cooling System Components

(1) Engine water jackets.

(a) In the cylinder block of a liquid cooled engine, water jackets completely surround all cylinders along their full length. Within the jackets, narrow passages are provided between the cylinders for coolant circulation.

(b) In the cylinder head, water jackets cover the combustion chambers at the top of the cylinders and contain water passages around the valve seats when the valves are located in the head. The watertight seal at the passages, as well as the gas tight seal at the combustion chamber opening, is obtained with one large gasket called the cylinder head gasket.

(2) Water pump.

(a) Automotive engines use a centrifugal type pump, driven by a belt, that consists of a round plate which has blades or vanes on one side of it.

(b) The plate, or impeller, is fastened to a turning shaft. As the impeller turns, it forces the coolant to circulate through the entire cooling system.

(3) Radiator.

(a) The radiator is normally mounted in front of the engine so cool air can pass freely through the core.

(b) The outlet on the bottom radiator tank is connected to the water pump inlet and the top tank inlet of the radiator is connected to the coolant outlet at the top of the engine.

(c) Rubber hoses and hose clamps are used to make connections and to prevent engine vibrations from being transferred to the radiator.

(d) Hot coolant is pumped out of the engine into the top radiator tank and flows through tubes into the core to the bottom tank. As the coolant makes its way down the tubes, it gives off heat that is transferred to air fins and finally to cooling air as it passes between the fins.

(e) By the time coolant reaches the bottom radiator tank, it is cool enough to be reused in the engine.

(4) Fan.

(a) To speed up the cooling action of the radiator, a fan is used to draw air through the radiator core. The fan also blows air on the engine to provide some direct air cooling on the engine.

(b) On some vehicles, a fan is bolted to and turns with the water pump shaft. In this way, the water pump and fan are driven by the same V-belt.

(5) Shroud.

(a) To prevent air from bypassing the radiator, a funnel-shaped component called a shroud is installed.

(b) The large end of the shroud is bolted to the radiator frame with the smaller end extending out to enclose the fan.

(6) Thermostat.

(a) The thermostat helps to speed up engine warm-up by recirculating coolant to the engine block through the bypass, thus avoiding the radiator.

(b) An element in the thermostat expands when heated and contracts when cooled.

(c) When the element is heated, the valve opens, permitting coolant to flow through the radiator.

(d) When the element cools, the valve closes, so that the main coolant flow recirculates within the engine.

(7) Recovery bottle.

(a) The recovery bottle serves as a coolant reservoir and receives radiator overflow through a hose.

(b) It is also used to check the level of the coolant and for adding coolant to the system.

(8) Pressure radiator cap.

(a) Engines employed in our tactical wheeled vehicles have pressurized cooling systems. Water boils at about 212 degrees Fahrenheit at sea level. If the pressure is increased, the water will not boil until a higher temperature is reached. Without pressurizing, the cooling system must be designed to prevent the coolant from reaching 212 degrees Fahrenheit. But if the system is pressurized, coolant temperature can be raised to about 260 degrees without boiling. This higher temperature allows the cooling system to operate more efficiently. Since coolant enters the radiator at a higher temperature, temperature difference between the coolant and the surrounding air is greater. This causes a greater heat transfer.

(b) A pressure radiator cap pressurizes and regulates the cooling system. The cap has two spring loaded valves that are normally closed, sealing the system. The largest of the two valves is the pressure valve, and the smaller a vacuum valve. When the cap is installed on the radiator filler neck, it seals at the bottom as well as the top of the filler neck.

(c) When the engine is cold, there is no pressure in the cooling system. As coolant in the system warms up, it expands. Since the cooling system is sealed by the radiator cap, the coolant expansion causes pressure to build. When the pressure builds enough to overcome spring tension holding the pressure valve closed, it lifts the valve.

(d) The excess pressure escapes by way of a pressure valve to pass through the hose in the filler neck to the coolant recovery bottle. The amount of pressure the cooling system is able to build up depends on the strength of the pressure valve spring.

(e) When the coolant temperature falls, pressure in the system drops and creates a vacuum, causing the vacuum valve to open. As the vacuum is relieved, coolant is siphoned back from the recovery bottle to the radiator to keep the system full.

c. Coolants

(1) Water is the most popular coolant for engines, but water without an inhibitor or rust preventative will cause corrosion and the formation of scale within the system.

(2) A solution of antifreeze and water not only protects the cooling system from freezing but also contains inhibitors to prevent corrosion.

## 4. AIR INDUCTION AND EXHAUST SYSTEMS

a. Air Induction System

(1) Induction of clean air plays an important role in engine operation and, unfortunately, is often overlooked.

(2) Particles of dust or sand entering the engine will cause severe damage and reduce engine life.

(3) To prevent foreign material from entering the engine, we employ an air induction system.

(a) The air intake stack is a section or sections of tubing that directs air to the air cleaner assembly and is connected by hoses and clamps.

(b) The air cleaner assembly houses a filter element that traps and prevents foreign particles from entering and damaging internal components of the engine.

(c) A combination of tubing and hoses continue from the air cleaner to the intake manifold, providing clean filtered air to the engine.

(d) An air restriction indicator is a device that displays a color band when a restrictive condition exists in the air induction system.

b. Exhaust System

(1) The exhaust system is a relatively simple part of the tactical wheeled vehicle. However, it plays an important role.

(2) Exhaust gases from the engine contain carbon monoxide which is a colorless, odorless, and deadly poisonous gas.

(3) Never run an engine for more than a minute or two unless it is located in a well-ventilated area; otherwise, you may become a victim of carbon monoxide poisoning.

(4) When performing maintenance on an exhaust system, be careful that you don't burn yourself on any of the hot exhaust system components.

(a) The exhaust manifold collects burned gases as they are expelled from the engine cylinders and directs them into the exhaust pipe.

(b) The exhaust pipe is the passageway for exhaust gases to flow from the manifold to the muffler.

(c) The purpose of the muffler is to reduce pressure of the exhaust gases and discharge them with a minimum of noise.

(d) The tail pipe carries exhaust gases from the muffler outlet to a point where they can safely be ejected.

## 5. POWER TRANSMISSION SYSTEM

### a. Clutch

(1) The clutch is located behind the engine of vehicles that employ manual transmissions.

(2) The clutch allows the driver to connect and disconnect the engine from the transmission. This is essential for starting the engine, gradual engagement of the engine to the power train, and allowing gear ratios to be changed to meet varying road conditions.

(3) A friction disk is mounted on the transmission input shaft with splines. When the friction disk is driven, it turns the transmission input shaft.

(4) The clutch also has a pressure plate assembly, which includes a series of coil springs. The pressure plate and cover assembly is attached to the engine flywheel.

(5) The springs provide pressure to hold the friction disk against the flywheel. Then, when the flywheel turns, the pressure plate and friction disk also turn.

(6) When the clutch pedal is depressed, the spring pressure is relieved so the friction disk and flywheel can rotate separately. The flow of power to the remaining drive train components is broken.

b. Manual Transmission

(1) An internal combustion engine develops maximum torque only at high speed and the crankshaft always rotates in the same direction. For these reasons, a transmission is employed in automotive vehicles. The transmission provides the mechanical advantage that enables the engine to propel the vehicle efficiently under various load and driving conditions. It also provides the driver with a selection of speeds while the engine is held at speeds within the effective torque range, and it allows disengaging and reversing the flow of power from the engine to the wheels.

(2) Enclosed in the transmission case are several sizes of large and small gears, so arranged that they may be meshed together to give different degrees of power or speed in relation to the turning speed of the engine crankshaft.

c. Automatic Transmission. Tactical vehicles that employ automatic transmissions do not have clutch mechanism per se. However, a torque converter is employed. A torque converter is a fluid coupling and can be illustrated by the action of two electric fans facing each other, one with the power connected and the other with the power disconnected. As the speed of the power-driven fan is increased, the flow of air transmits power to the motionless fan and it begins to rotate. The free-running fan gains speed until it is rotating almost as rapidly as the power-driver fan. The same action takes place in the torque converter except oil instead of air transmits the power.

d. Transfer Case

(1) Transfer assemblies are used in our tactical vehicles to divide engine torque between the front and rear driving axles.

(2) The transfer case allows the front driving axle to be disengaged, which is necessary to prevent undue driveline-component wear during highway use.

(3) The transfer case also provides full time torque to the rear axle and provides a high and low drive gear range.

(4) Some transfer assemblies use a chain and some use gears to transmit torque to the front driving axle.

e. Universal Joint

(1) A universal joint is a flexible coupling between two shafts that permits one shaft to drive another at an angle to it.

(2) A universal joint is composed of three fundamental units consisting of one journal and two yokes.

(3) The two yokes are set at right angles to each other, and their open ends are joined by a journal.

(4) This construction permits each yoke to pivot on the axis of the journal and also permits transmission of rotary motion from one yoke to the other.

(5) As a result, universal joints can transmit the power from the engine through the shaft to the drive axle.

f. Slip Joint

(1) A slip joint consists of a male and female spline, a grease seal, and a lubrication fitting.

(2) The male spline is an integral part of the propeller shaft and the female portion is fixed to the universal joint directly behind the transmission or transfer case.

(3) This gives freedom of movement in a horizontal direction and yet is capable of transmitting rotary motion.

g. Propeller Shaft

(1) The propeller shaft, the central component in the drive train assembly, is constructed from a hollow steel tube with yoke ends welded to it.

(2) Large tactical vehicles use a split propeller shaft, which reduces the length of each shaft and operating angle of each universal joint. A split propeller shaft requires some additional parts, such as another universal cross and bearing cup assembly, two more forged steel yokes, a slip joint, and a center bearing mounted in a rubber cushioned bracket or carrier bearing, commonly referred to as a pillow block.

h. Differential Assembly

(1) One purpose of the differential is to transmit engine torque to the driving axles that are on a ninety degree angle to the propeller shaft.

(2) Another purpose of the differential is to divide engine torque between driving wheels so they are free to rotate simultaneously at varying speeds. This is important if the vehicle is not moving in a straight line.

(3) A bevel drive pinion rotates the bevel drive ring gear and the rotation of the ring gear causes the differential case to rotate.

(4) When the differential case rotates, two pinion gears and their shaft move around in a circle with the differential case.

(5) Because the two differential side gears are meshed with pinion gears, the differential side gears must rotate, thus causing the rear axles to rotate. The wheels turn, and the vehicle moves.

(6) Suppose one rear wheel is held stationary. If the differential case rotates, the pinion gears would have to rotate on their shaft.

(7) The pinion gears would walk around the stationary differential side gear.

(8) As the pinion gears rotate on their shaft, they carry rotary motion to other differential side gear, causing it to rotate. The other wheel that is not stationary will then rotate.

(9) Whenever a four-wheel drive vehicle goes around a turn, the outer wheels travel a greater distance than the inner wheels. The pinion gears rotate on their shaft and send more rotary motion to the driving wheel.

(10) When the vehicle is moving down a straight road, the pinion gears do not rotate on their shaft, but apply equal torque to the differential side gears. Therefore, both rear wheels rotate at the same speed.

## 6. AUTOMOTIVE BRAKES

a. General Information. During this portion of the lesson, I will provide a basic introduction to the construction and operation of the various types of automotive brake systems. The specific types of brake systems employed on our tactical wheeled vehicles will be addressed in detail as you progress through the instructional modules.

b. Function and Type of Brakes

(1) The purpose of brakes is to slow and stop the vehicle. They may be hydraulic, air pressure, or a combination of the two. However, they all function in the same manner.

(2) An operating device forces brake shoes or pads against the rotating drums or disks at the wheels when the driver operates the brake pedal.

(3) Friction between brake shoes or pads and brake drum or disks, then slows or stops the wheels, so the vehicle is braked.

c. Hydraulic Braking Action. Fluid is not compressible. Pressure on a fluid will force it through a tube and into chambers or cylinders, where it can force pistons to move. This is the principle on which hydraulic brakes work.

(1) Hydraulic type brakes use pressure of a fluid to force the brake shoes outward and against the brake drum or disk.

(2) In operation, a downward movement of the brake pedal forces a piston to move in the master cylinder. This applies pressure to fluid ahead of the piston, forcing fluid under pressure through the brake lines to wheel cylinders in drum type brakes and to pistons in disk type brakes.

(3) On drum type brakes, a piston within the wheel cylinders is linked to the brake shoes. When fluid is forced into the wheel cylinder, the piston is pushed outward.

(4) This outward movement forces the brake shoes outward and into contact with the brake drum, slowing or stopping the vehicle.

(5) When the brake pedal is released, tension of the brake shoe springs forces the brake shoes away from the drum and pushes the wheel cylinder piston inward.

(6) Disk type brake has a rotor instead of a drum, and pads instead of brake shoes.

(7) Once the brake pedal is depressed, fluid enters the caliper and pushes the piston outward, forcing the pad against the moving rotor, slowing or stopping the vehicle.

(8) When the brakes are released, a seal on the piston relaxes and draws the piston away from the disk.

d. Air Brakes

(1) An air pump or compressor driven by the engine is used to compress air and force it into a reservoir where it is available for operating the brakes.

(2) Air under pressure in the reservoir is released to the brake lines by an air valve operated by the brake pedal.

(3) This released air goes to brake chambers, that are located close to the wheel brakes, which contains a flexible diaphragm.

(4) Against the diaphragm is a plate that is connected directly to the mechanism on the wheel brakes by linkage.

(5) The force of the compression air is admitted to the chamber and causes the diaphragm to move the plate and operate the brake shoes through the linkage, slowing or stopping the vehicle.

(6) When the air pressure is reduced by the operator releasing the brake pedal, the diaphragm moves, opening the exhaust port and exhausting the compressed air pressure from the brake chamber. The brake shoe spring pulls the brake shoes away from the drum.

e. Air-over Hydraulic Brakes

(1) As with the straight air brake system, air pressure is supplied by a compressor and stored in reservoirs.

(2) The master cylinder is similar to the master cylinders used in hydraulic brakes. Also wheel brake cylinders and wheel brake construction are very similar to that used in hydraulic brakes.

(3) The essential difference between the straight hydraulic brake system and air-over hydraulic brake system lies in the air-hydraulic cylinder.

(4) The air-hydraulic cylinder consists of an air cylinder and a hydraulic cylinder in tandem, or one behind the other, each fitted with a piston.

(5) The air piston has a larger diameter than the hydraulic piston. This difference in size of the two pistons provides greater hydraulic pressure than the air pressure admitted to the air cylinder.

(6) Valves, actuated by fluid pressure from the master cylinder, control the air admitted to the air cylinder. Thus, fluid pressure in the brake lines is always in a direct ratio to foot pressure on the brake pedal.

In other words, the heavier the brake pedal pressure, the stronger the braking action.

(7) When the brake pedal is released, the air in the air-hydraulic cylinder is vented, allowing tension of the brake return springs to pull the brake shoes away form the brake drum.

f. Substance Identification

(1) Asbestos is a fibrous material that was previously used in the manufacture of heat-resistant clothing, automotive brake and clutch linings, and a variety of building materials.

(2) Although asbestos is excellent for use in brake linings, brake pads and clutch disks because of its durability and capability to withstand heat, it can cause disabling respiratory diseases and various types of cancers if the asbestos fibers are inhaled or ingested.

(3) Recently manufactured brake linings and clutch disks do not contain asbestos fibers, but may contain one or more of a variety of ingredients, including glass fibers, mineral wool, and other ingredients that can present health risks if inhaled.

g. Work Practices

(1) Whenever feasible, service the brakes in a separate area away from other operations to reduce risks to unprotected persons.

(2) Always wear respiratory protection during brake servicing, beginning with the removal of the wheels.

(3) Some maintenance sections may have an enclosed vacuum system equipped with worker arm sleeves. The vacuum system is used to loosen and vacuum residue from the brake parts.

(4) If an enclosed vacuum system is not available, carefully clean brake parts in open air, using a solution containing water and if available, a biodegradable non-phosphate, water-based detergent.

(5) The wheel, hub and brake assembly components should be thoroughly wetted with a spray bottle that creates a fine mist to suppress any dust before the brake shoes or pads are removed, then wiped clean with a cloth.

(6) Never use compressed air to clean brake components and always discard contaminated material in accordance with your unit's SOP.

## 7. SUSPENSION AND STEERING SYSTEMS

a. Suspension System. The purpose of the suspension system is to support the weight of the vehicle and its load. It is an important part of any vehicle and is particularly important in tactical wheeled vehicles which are often very heavy and must provide for absorption of road shocks, and be efficient over a wide range of speed and load conditions.

(1) As stated earlier, the vehicle frame supports the weight of the engine, power train components, body, cargo, and passengers.

(2) The frame is supported by springs placed between the frame and wheel axles.

(3) The weight of the frame, engine, and so on applies an initial compression to the springs. The springs will further compress or will expand, as the wheels encounter irregularities in the road. This allows the wheels to move up and down somewhat independently of the frame.

(4) This allows springs to absorb a good part of the up-and-down motion of the wheels, preventing this motion from being transmitted to the frame and supported components.

(5) A multileaf spring is made up of a series of flat steel plates of graduated length placed one on top of another.

(a) Clips, placed at intervals along the spring, keep the leaves in alignment and a center bolt holds the leaves together.

(b) In operating, the leaf spring acts much like a flexible beam.

(6) Coil-type springs are made of round spring steel wound into a coil.

(a) The sole purpose of coil springs is to support the weight of the vehicle.

(b) Coil springs are not able to absorb any torque when employed in the suspension system, and require the use a shock absorber to dampen vibrations.

(7) The primary function of the shock absorber is to regulate the suspension spring rebound so the primary vibrations are damped out, permitting greater vehicle speed and mobility.

(a) Hydraulic shock absorbers are use on our tactical wheeled vehicles and contain a fluid that is forced through orifices as the shock absorber is operated by spring flexure.

(b) Resistance to the movement of the fluid through the orifices creates a drag on spring movement, which quickly dampens out vibrations.

b. Steering System. The steering system permits the front wheels to be pivoted on their supports to the right or left so the vehicle can be steered.

(1) The steering wheel is mounted on a steering shaft that extends into a steering gear.

(2) The bottom end of the shaft has a gear that rotates as the wheel is turned. This movement causes the pitman arm, attached to the sector, to swing to right or left.

(3) This action pushes or pulls on tie rods attached to the pitman arm. Steering-knuckle arms, attached to the front wheels are forced to swing the wheels to the right or left on their pivots allowing the operator to steer the vehicle.

**REFERENCE**:

TM 9-8000