CDC Y2T35X

Mission Generation Vehicular Equipment Maintenance Journeyman

Volume 2. Suspension, Steering, and Brake Systems

Air Force Career Development Academy

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Author: MSgt Dylan V. Petersen
344th Training Squadron, Detachment 1
Vehicle Management School House (AETC)
344 TRS, Det 1/TTAD
480 West Road
Naval Base Ventura County, Port Hueneme, California 93043
DSN: 551-1095
E-mail address: 344TRSDet1.CDC.Contact@us.af.mil

Instructional Systems Specialist: Todd Knowles

Editor: Marie Lacayo

Air Force Career Development Academy (AFCDA)
Air University (AETC)
Maxwell AFB-Gunter Annex, Alabama

WELCOME TO Volume 2, *Suspension, Steering, and Brake Systems,* of the Career Development Course (CDC) Y2T35X, *Mission Generation Vehicular Equipment Maintenance Journeyman*. In this volume, you will learn about suspension, steering, and brake systems found on modern vehicles. These systems are critical in ensuring the driver is able to safely control the vehicle while in operation. While an engine or drivetrain failure may keep a vehicle from accomplishing the mission, it is likely to only result in an immobilized asset. A failure in one of these systems has an increased likelihood of causing injury or death.

All four units contain information derived from the textbook, *Modern Automotive Technology, 9th Edition*, written by James E. Duffy, and published in 2017 by The Goodheart-Willcox Company, Inc., Tinley Park, IL. The respective reading assignments and study questions (both review and Automotive Service Excellence [ASE]-type) have been carefully selected to increase your knowledge and comprehension of both subject matter and tasks required of journeymen within your career field. To assist you, the correct responses to the study questions are provided at the end of both units. The CDC writer and Air Force Career Development Academy (AFCDA) personnel have methodically researched and verified these responses to ensure their accuracy.

Unit 1 will cover tires, wheels, and wheel bearings. You will learn how these components are constructed to provide safe and dependable service.

Unit 2 will discuss suspension systems. You will learn how suspension is constructed to allow vehicles to ride smoothly over rough terrain and provide a safe and comfortable means of transportation.

Unit 3 will teach you about steering and alignment. You will learn how the components of the steering system allow the driver to safely maneuver the vehicle, and how the vehicle's alignment contributes to safety, handling, economy, and tire life.

Unit 4 will cover brakes and control systems. You will learn how braking systems provide a safe means of slowing, stopping, or holding a vehicle, and how advanced control systems, such as anti-lock brakes, improve vehicle safety.

A glossary is included in the textbook *Modern Automotive Technology, 9th Edition*, for your use. Further, if you encounter any measurement-related acronyms with which you are unfamiliar, please refer to Figures 6-1 and 6-3 on pages 90-91 in the textbook for an explanation.

Code numbers on figures are for preparing agency identification only.

The use of a name of any specific manufacturer, commercial product, commodity, or service in this publication does not imply endorsement by the Air Force.

To get a response to your questions concerning subject matter in this course, or to point out technical errors in the text, unit review exercises, or course examination, call or write the author using the contact information provided in this volume.

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For Guard and Reserve personnel, this volume is valued at 32 hours and 8 points.

NOTE:

In this volume, the subject matter is divided into separate units. Although some units have lessons that are self-contained, each unit incorporates lessons derived from the textbook *Modern Automotive Technology, 9th Edition*. A unit menu begins each unit, identifying the lesson headings, assigned readings, self-test questions and/or textbook review questions. After reading the unit menu page and unit introduction, study the reading assignment, answer the indicated questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

Page

Please read the menu for Unit 1 and begin ➔

Unit 1. Tires, Wheels, and Wheel Bearings

TIRES, WHEELS, AND BEARINGS provide the connection for vehicle engine power to be transferred into movement. It is literally, where the rubber meets the road. In this unit, we will begin by looking at basic facts referencing a tire, wheel, and bearing. Then we will discuss some techniques to facilitate the diagnosis and repair for these systems.

It is important to be knowledgeable and proactive when it comes to wheel and tire systems. A great deal of damage, even injury or death, can result from improper maintenance. Even during a normal walkaround inspection, proper maintenance procedures may be overlooked. This can have a significant impact in the event of a tire blowout while driving.

201. Tire, wheel, and bearing fundamentals

In this lesson, you will learn the fundamental concepts of tire, wheel, and bearing assemblies. We will cover what types there are, what their purposes are, and how to interpret markings on tires.

This lesson is broken up into two parts. The first portion includes the assigned reading in the textbook *Modern Automotive Technology, 9th Edition*, along with review and Automotive Service Excellence (ASE)-type questions. The purpose of ASE is mentioned in the first few pages of the textbook. The second part of the lesson consists of reading within this unit, along with self-test questions after the second lesson within this unit. In both cases, you will find the correct responses at the end of the unit.

To begin the lesson, please refer to *Modern Automotive Technology, 9th Edition* and the following table for the assigned reading questions.

Assigned Material		
Task	**Material**	**Pages**
Read	Chapter 73: Tire, Wheels, and Wheel Bearing Fundamentals	1449–1463
Answer	Review Questions: 1, 4, 5, 6, 7, 8, 9, 11, 12	1464
Answer	Automotive Service Excellence-Type Questions: 3, 4, 5, 11, 14	1465–1466

Heavy-duty wheels

Many of the vehicles in the Air Force inventory are heavy duty, industrial vehicles. The following information, with proper on-the-job training, will help you safely service tires mounted to wheels not commonly found on passenger cars and light-duty trucks.

Wheels (often referred to as a rim) are designed to support the tire while withstanding loads from acceleration, braking, and cornering. Wheels can be made of steel, cast aluminum, or magnesium. Two components comprising a standard wheel include the *rim* (outer lip that contacts tire bead) and the *spider* (center section that bolts the wheel to the vehicle). Normally, the spider is welded to the rim. Some other wheel-related items include the valve stems, valve cores, lug nuts, and lug bolts or studs.

Large single-piece wheel and tire assembly

A number of the large vehicles you encounter will use a large single-piece wheel and tire assembly. With the exception of its size and heavy metal construction, this type of wheel is very similar to those found on light duty passenger vehicles. It incorporates a *safety* feature to hold the tire beads on the wheel during a tire blowout or flat.

For example, small raised lips on the rim housing keep the tire beads from sliding inward during these hazardous conditions and help prevent the tire from coming off the wheel. Tubeless tires are most commonly used on this type of wheel.

Split rim wheel and tire assembly

Many special-purpose industrial vehicles (small tires on forklift, tugs, etc.) use another type of split wheel (fig. 1–1). This type of wheel does not use a series of side rings or lock rings. Literally, the rim is split into two pieces or halves. The two halves are bolted together with high-strength bolts and nuts. The usually flat-shaped designed bolt head prevents its removal unless first removing the wheel. Lastly, the nut end of the bolt should face toward the inside of the wheel.

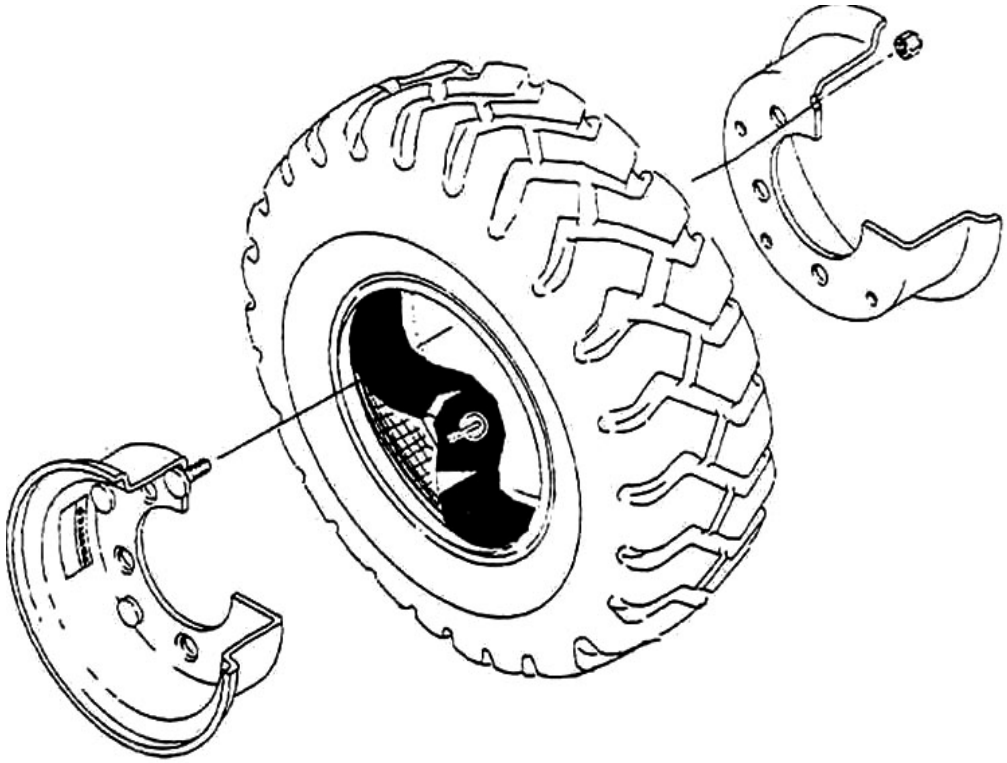

Figure 1–1. Split rim wheel.

Split ring wheel and tire assembly

A split ring (or multi-piece) wheel and tire assembly is comprised of several interlocked components to hold the tire on the rim housing when inflated. They have either a side ring or a side and lock ring combination. These parts are removable from only one side for tire replacement. Finally, this type of wheel usually comes in a two- or three-piece design and uses either tube or tubeless tires.

Two-piece wheel

A two-piece wheel consists of a split side ring and rim housing (fig. 1–2). The split side ring retains the tire bead on one side of the rim and the rim's fixed flange retains the other side's tire bead. The split side ring is designed to act as a self-contained lock ring as well as a flange. The lip of the split side ring fits into the gutter area of the rim and locks into place (fig. 1–3).

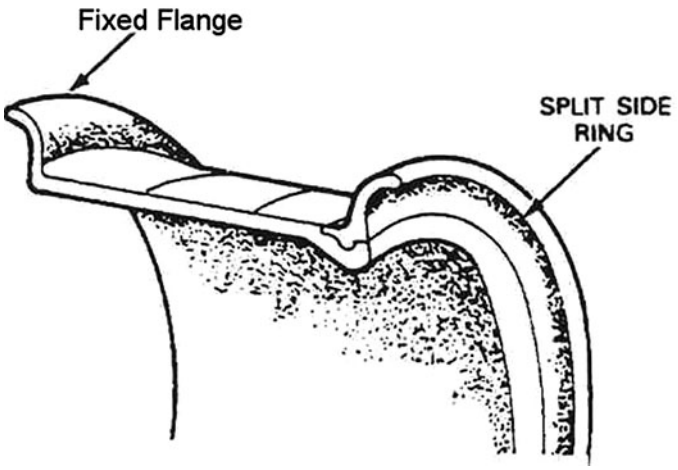

Figure 1–2. Two-piece wheel.

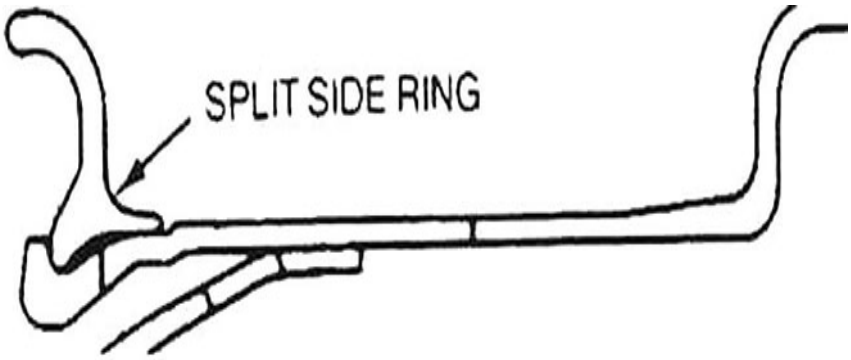

Figure 1–3. Two-piece rim section.

Three-piece wheel

The three-piece wheel consists of a continuous (not split) side ring, split lock ring, and a rim housing (fig. 1–4). The continuous side ring supports the tire on one side, but it is not split as the side rings in the two-piece design. A split lock ring holds the continuous side ring in place by. The lock ring is wedged between the side ring and the rim's gutter (fig. 1–5).

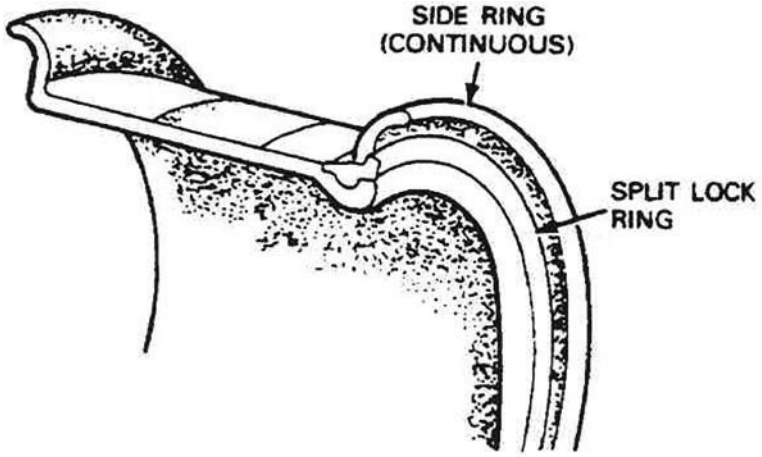

Figure 1–4. Three-piece wheel.

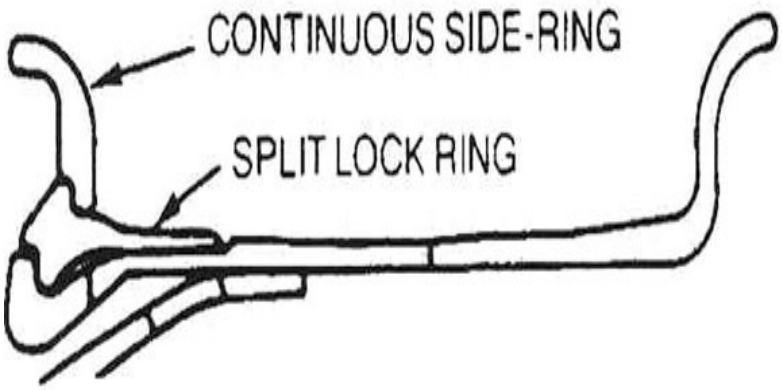

Figure 1–5. Three-piece rim section.

Component matching

Most highway wheels look alike, but some may vary with certain design features. The differences between rims of different types is what makes “part mixing” a dangerous business. A close, proper fit between rim parts is essential for long tire life as well as safe operation. Very often, side rings and lock rings of different types may appear properly seated. However, upon further inspection, they do not fit properly. Mismatched rim components usually create an unsafe condition.

Federal law mandates the rim size and type be stamped on the wheel and rim components. Other required information includes the name of the manufacturer, when manufactured, and the country where manufactured.

Deflate tires before removal

The following two conditions require deflating a tire prior to removing it from a vehicle:

1. The tire has been driven underinflated; that is, at 80 percent or less of its recommended pressure.
2. There is obvious or suspected damage to the tire and rim components.

First, under inflation can cause the interlocking surfaces of the rim components to wear down. Second, the wheel and rim components could become misaligned. If either of these problems are the case, the components could explosively separate while loosening the lug nuts. Keep in mind that the lug nut clamps may be all that is holding a cracked rim together.

When removing from the vehicle a split ring (multi-piece) wheel for replacement or repair, deflating it is always a good trade practice. This does not mean that a tire requires deflating if you remove it to service other components (brakes, suspension, etc.). Of course, if damage to any rim component is suspected or evident, completely deflate the tire before you loosen the lug nuts. Removal of the valve core from the valve stem should allow the tire to deflate completely.

Trajectory zone

Whenever handling inflated truck tires, stay out of the trajectory (danger) zone (fig. 1–6) as much as possible. The *trajectory zone* is an expected movement path of rim components should they burst apart unexpectedly. There are times when going into the trajectory zone is necessary. For example, checking the air pressure of a tire or connecting an air chuck to the valve stem are two tasks that require a person to enter the trajectory zone.

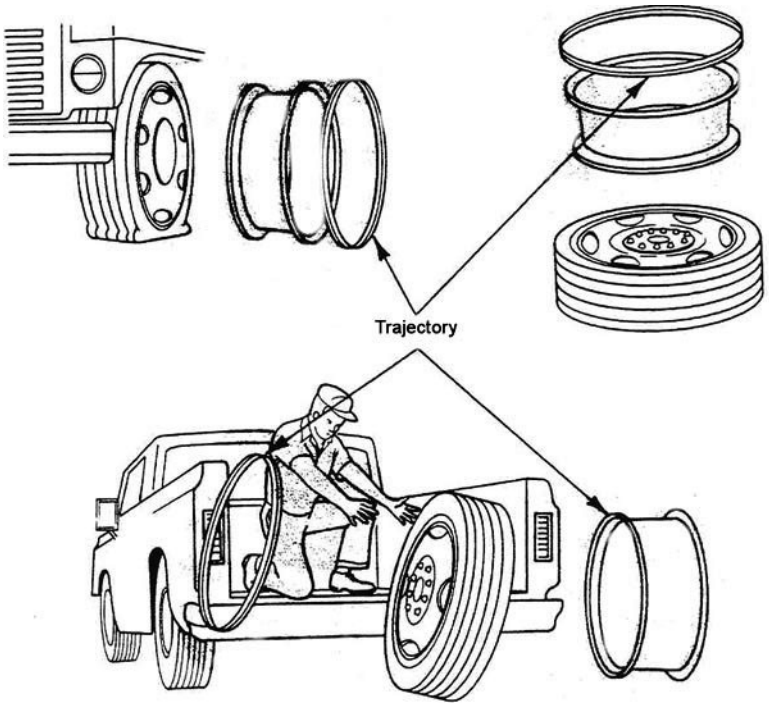

Figure 1–6. Trajectory zone.

Use a long air hose (approximately 5 feet) equipped with a clip-on air chuck, an inline valve or gauge to inflate a tire while installed on the vehicle. The clip-on chuck attaches to the tire's valve stem, preventing the continual need to hold it to the stem by hand. The inline valve or gauge allows adding air and monitoring the tire while you are out of the trajectory zone.

202. Tire, wheel, and bearing diagnosis and repair

With good foundational knowledge, you can now begin troubleshooting, diagnosing, and repairing these components. In this lesson, you will become familiar with techniques that will help you identify faults that can be fixed in a shop or driveway and avoid extensive and costly damage to a vehicle.

As with the previous lesson, this lesson is broken up into two parts. The first includes the assigned reading in the textbook *Modern Automotive Technology, 9th Edition*, as well as review and ASE-type questions. The second part of the lesson consists of reading within this unit, along with self-test questions after the second lesson within this unit. In both cases, you will find the correct responses at the end of the unit. To begin this lesson, please refer to *Modern Automotive Technology, 9th Edition* and the following table for the assigned reading and questions.

Assigned Material		
Task	**Material**	**Pages**
Read	Chapter 74: Tire, Wheel, and Wheel Bearing Diagnosis and Repair	1467–1486
Answer	Review Questions: 1, 3, 8, 13	1486–1487
Answer	ASE-Type Questions: 2, 3, 7, 9, 13	1487–1488

Heavy-duty wheel service

When servicing heavy-duty wheels, there are a few additional points to consider when compared to servicing passenger and light-duty truck tires.

In addition to being larger and more difficult to handle, you know from the previous lesson that they may use different types of rims as well. As such, the equipment and techniques used on smaller tires may not be effective. The remainder of this lesson will discuss tools and techniques to safely service heavy-duty tires and wheels.

Wheel dolly

Use a wheel dolly (fig. 1–7) when removing heavy wheels, rims, or tires. The use of a wheel dolly can help prevent back injuries resulting from the lifting of a heavy or awkward shaped wheel and tire assembly. The wheel dolly also allows easy maneuvering of the tires during installation. If a wheel dolly is unavailable, have a helper assist you with removal; be sure to always follow proper handling and lifting techniques.

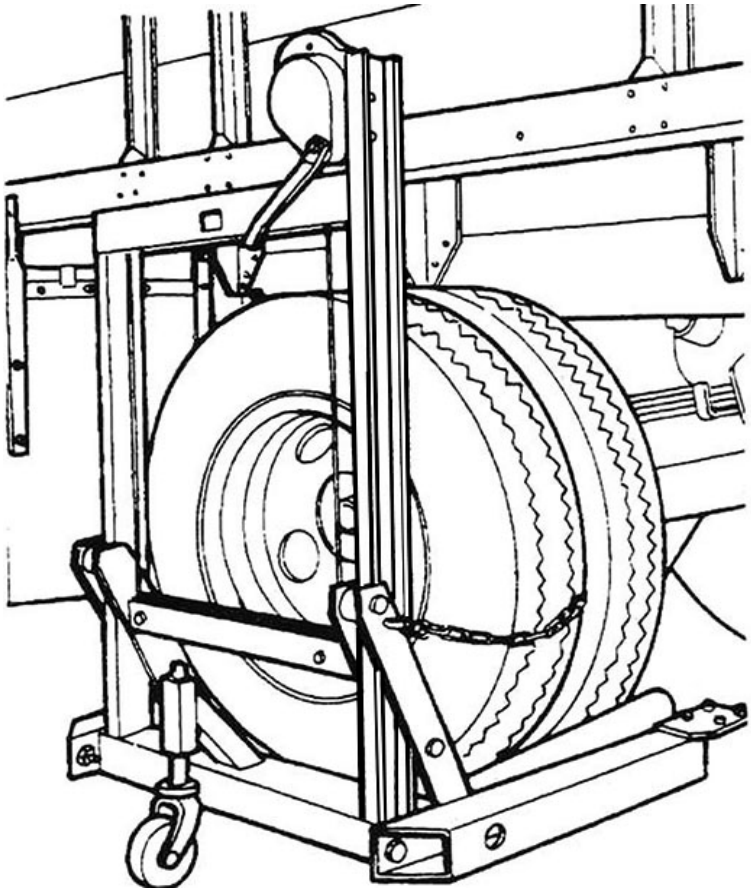

Figure 1–7. Wheel dolly.

Dismounting/mounting

As stated in the previous lesson, always deflate the tire before removing it from a vehicle driven underinflated or if there is damage to the tire and rim components. When dismounting or mounting the tire from a rim assembly, be sure to follow all the procedures outlined in the service manual or technical order.

Large single-piece wheel and tire assembly

Most vehicle management shops are equipped with tire changing machines to ease tire removal and installation. However, this may not always be the case. Ensure you are properly trained to service wheel and tire assemblies, regardless of design.

The following are seven general procedures for dismounting and mounting tires on single-piece wheel and tire assemblies:

1. Carefully remove the wheel and tire assembly from the vehicle, placing it on a machine or shop floor.
2. Remove the valve stem core and deflate the tire (if not already deflated).
3. Carefully break the bead with the appropriate machine or by hand using a large slide hammer. Inch it off a little at a time, working around the tire to prevent damage to the beaded area.
4. Insert two tire irons about six inches apart between the upper bead and rim. Kneel on the tire opposite the tire irons and pry the tire bead over the rim flange (lip). Work the tire irons progressively around the rim until the tire is removed.
5. Inspect the wheel and tire assembly surface for damage or corrosion. Lightly lubricate the tire beads and mount the tire on the wheel in reverse order as removal.
6. With the valve stem core removed, inflate the tire to approximately 15 pounds per square inch (psi) in order to seat the tire bead. If the bead fails to seat properly against the rim, double check the rim surface and re-lubricate the tire bead.
7. Once the bead is properly seated, install the valve core stem and place the wheel and tire assembly in a tire safety cage. Inflate tire to the proper specifications.

NOTE: Light-duty tires typically do not require inflation in a safety cage.

Tire removal procedures are similar with split ring (multi-piece) wheel and tire assemblies. Always follow the service manual or technical order for the proper step-by-step procedures when dismounting and mounting tires from a wheel assembly.

Split rim wheel and tire assembly

The split rim wheel and tire assembly is made up of two pieces bolted together. Once the tire is deflated, unbolt the nuts and separate the two halves to service the tire. Re-assemble the wheel in reverse order and torque the nuts to specifications. Follow specific guidelines in the service manual or technical order when re-assembling this type of wheel.

Split ring wheel and tire assembly

The split ring wheel and tire assembly comes in either the two- or three-piece wheel design. When servicing these types of wheels, always follow the step-by-step procedures outlined in the service manual or technical order.

Two-piece wheel design

Refer to figure 1–8 to view basic procedures for dismounting the tire from a typical two-piece wheel. Be sure to follow the exact instructions in the service manual or technical order for each type of rim. Figure 1–9 shows the basic mounting procedures.

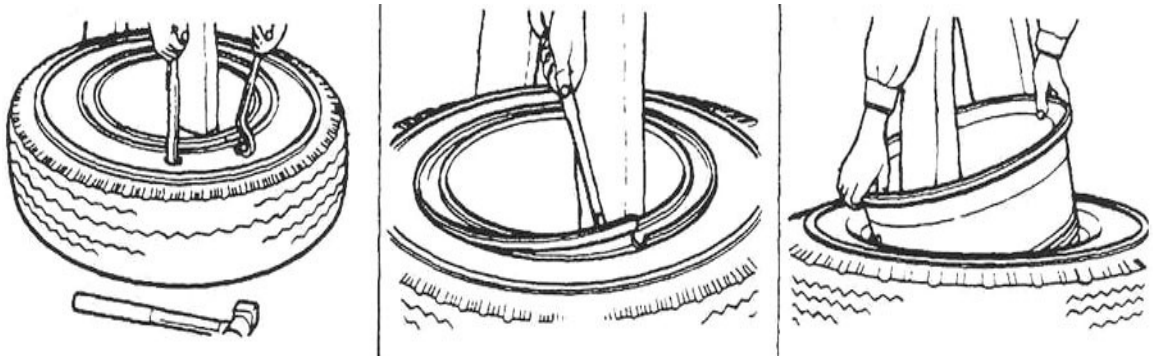

Figure 1–8. Disassembling a two-piece rim.

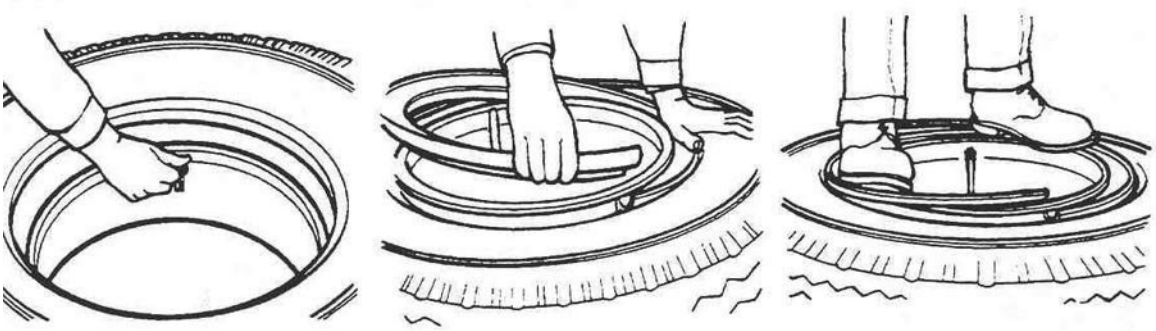

Figure 1–9. Assembly of a two-piece rim.

Three-piece wheel design

Refer to figures 1–10 and 1–11 to view basic procedures for dismounting and mounting a tire on a typical three-piece wheel. Mounting and dismounting procedures between the two-piece and three-piece wheel are similar. Take your time during the mounting process to ensure you assemble the rim correctly. During mounting, do not try to seat lock rings or side rings by hammering the components, especially if the tire is inflated or partially inflated. Properly matched components assemble and seat together without hammering. If it is necessary to lightly tap components together, use a rubber, plastic, or brass-faced mallet. A steel hammer can damage the rim, side ring, or lock ring, possibly preventing the parts from seating properly. Be sure to follow the exact procedures in the service manual or technical order for each type of rim.

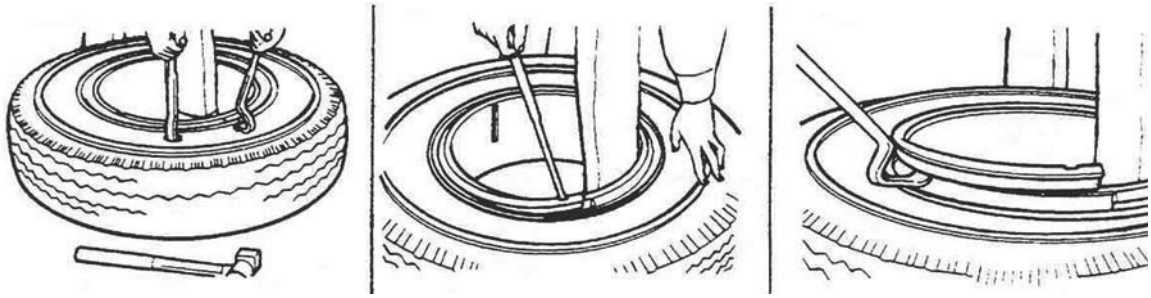

Figure 1–10. Disassembling a three-piece rim.

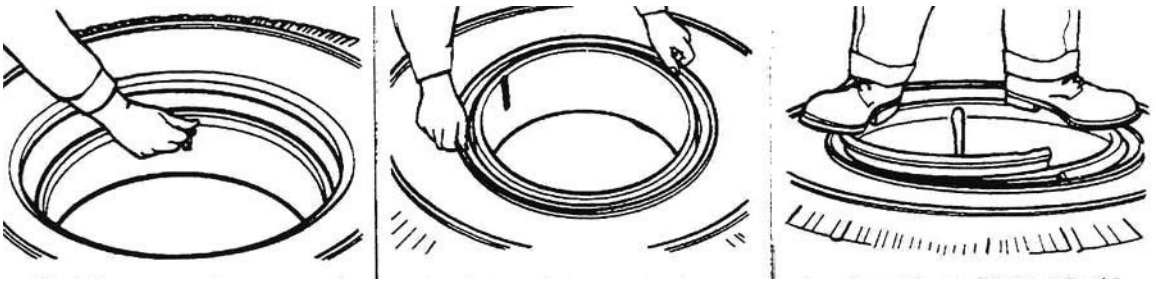

Figure 1–11. Assembly of a three-piece rim.

After you disassemble a multi-piece wheel, perform a thorough inspection of components. Inspect all metal surfaces for cracks, corrosion, bent/sprung components, and rust and deep tool marks in ring seating surfaces.

Replace all cracked, broken, or bent/sprung components. Replace the part if there is a loss of contour or metal thickness in the mating areas of side rings and lock rings because of rust or corrosion. Do not, under any circumstances, attempt to rework, weld, heat, or braze any rim components for any reason. You can clean minor rust and buildup with a wire brush.
Some manufacturers recommend that you paint the rim before reassembly to aid in rust prevention.

Follow the manufacturer's recommendations when selecting the correct kind of paint to use. Do not allow too much paint in the gutter areas where lock rings or side rings seat.

NOTE: If you replace a faulty rim component, be sure to destroy it before placing it in the scrap metal pile. This will prevent someone else from using it in the future. Use a cutting torch to cut the faulty component in such a way that it cannot be mistakenly reused.

Do not take any chances or be careless when dealing with multi-piece wheel components. If you are not sure about the proper mating of rim and wheel parts, consult a rim and wheel expert. This may be your immediate shop supervisor, a wheel distributor in your area, or the manufacturer's sales engineer. Remember, safety is of the utmost importance.

Caging the wheel and tire assembly

After you assemble the wheel components, place the wheel and tire assembly into an approved safety cage or restraining device. Most Air Force vehicle management shops use a safety cage like the one shown in figure 1–12. This particular tire cage is equipped with a regulator device and long hose/clip-on air chuck that allows the tire to be inflated without the technician placing his or her hands or body near the tire during inflation. A gauge on the regulator assembly also allows the operator to monitor the pressure from outside the cage.

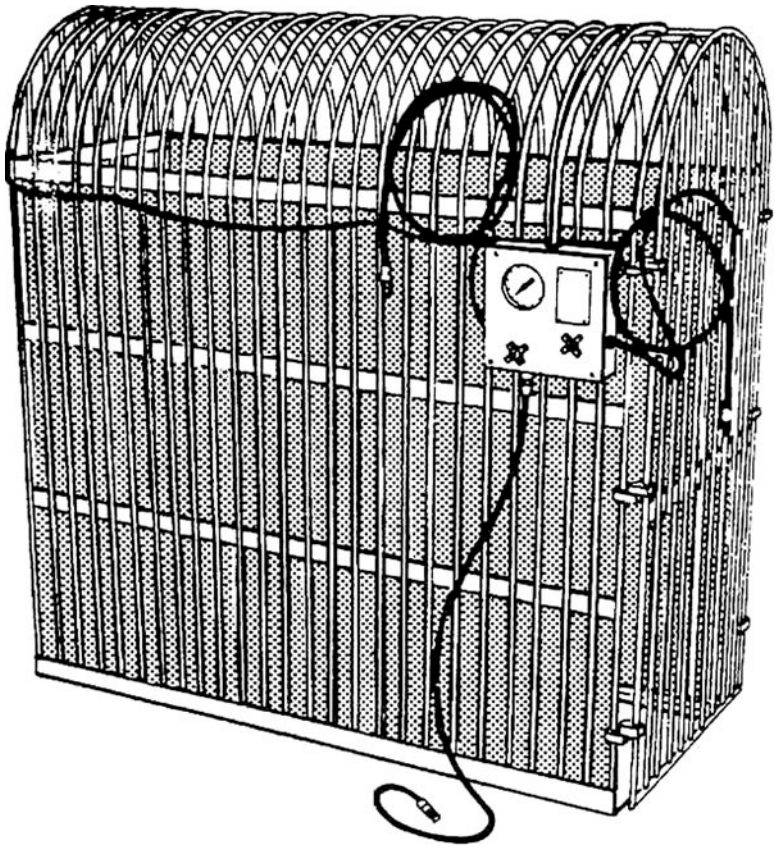

Figure 1–12. Tire safety cage.

Inflating the tire and checking for proper seating

It is critical to ensure proper seating. Therefore, with the valve core removed and the wheel and tire assembly in the cage, initially inflate the tire to approximately 15 psi and check for proper component seating. If wheel and tire assembly components are not properly seated, deflate the tire and disassemble the assembly to determine the problem.

If the wheel and tire assembly components are properly seated, deflate the tire, install the valve core, and re-inflate to the recommended operating pressure. Ensuring the correct pressure is a very important step for tube-type tires to prevent overstretching of the tube and flap. (A flap is also known as a liner.)

CAUTION: Do not lean on the tire cage or allow tools to lean against the cage. If an explosion occurs, the tools may fly in any direction and injure someone.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

201. Tire, wheel, and bearing fundamentals

1. What components comprise a standard wheel?

2. Explain the “safety” feature on light duty and large single piece wheel and tire assembly.

3. What type of wheel and tire assembly is split in half?

4. What type of wheel and tire assembly is comprised of several interlocked components?

5. What are two situations when you must deflate a tire before you remove it?

6. What does the term “trajectory zone” mean?

202. Tire, wheel, and bearing diagnosis and repair

1. What piece of equipment can help prevent back injuries when lifting heavy or awkward shaped wheel and tire assemblies?

2. Explain the process of removing a tire from a light duty or large single-piece wheel assembly.

3. What should *not* be done to seat lock rings or side rings on a three-piece wheel assembly?

4. If you replace a faulty rim component on a three-piece wheel assembly, what must you do with the old piece?

5. Why must a wheel and tire assembly be inflated in an approved safety cage?

Answers to Textbook Questions

201

Chapter 73 Review Questions

1. They act as a soft cushion between the road and the metal wheel, and they provide adequate traction with the road surface.
4. Rolling resistance.
5. (C) Lateral ply.
6. Information about tire size, tire model, load-carrying ability, inflation pressure, number of plies, speed rating, manufacturer, etc.
7. False
8. These tires have a coating of sealing compound applied to their liners. If a nail punctures a self-sealing tire, air pressure will push the soft compound into the hole to stop air leakage.
9. Safety rim.
11. Wheel weights.
12. (1) Outer race—A steel cup or cone pressed into hub, steering knuckle, or bearing support.
    (2) Balls or rollers—Antifriction elements that fit between inner and outer races.
    (3) Inner race—A cup or cone that rests on spindle or drive axle shaft.

Chapter 73 ASE-Type Questions

3. (A) A only.
4. (B) B only.
5. (B) B only.
11. (C) Both A and B.
14. (C) Both A and B.

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Chapter 74 Review Questions

1. Any order: vibrations, abnormal tread wear patterns, steering wheel pull, abnormal noises.
3. (B) B only.
8. Lateral runout is side-to-side movement. Radial runout is caused by a difference in radius from the center axis of rotation.
13. False.

Chapter 74 ASE-Type Questions

2. (C) Both A and B.
3. (B) B only.
7. (A) A only.
9. (A) A only.
13. (B) B only.

Answers to Self-Test Questions

201

1. Rim and the spider.
2. Tire beads are held on the wheel during blowout or flat. For example, small raised lips on the rim housing keep the tire beads from sliding inward during these hazardous conditions and help prevent the tire from coming off the wheel.
3. Split rim wheel.
4. Split ring (or multi-piece).
5. (1) The tire has been driven underinflated; that is, at 80 percent or less of its recommended pressure.
   (2) There is obvious or suspected damage to the tire and rim components.
6. An expected movement path of rim components should they burst apart unexpectedly.

202

1. Wheel dolly.
2. Carefully remove the wheel and tire assembly from the vehicle and place them on a machine or shop floor. Remove the valve stem core and deflate the tire (if not already deflated). Carefully break the bead with the appropriate machine or by hand using a large slide hammer. Inch it off a little at a time, working around the tire to prevent damage to the beaded area. Insert two tire irons about six inches apart between the upper bead and rim. Kneel on the tire opposite the tire irons and pry the tire bead over the rim flange (lip). Work the tire irons progressively around the rim until the tire is removed.
3. Hammering the components, especially if the tire is inflated or partially inflated.
4. Destroy the faulty component before placing it in the scrap pile.
5. This allows the tire to be inflated without the technician placing his or her hands or body near the tire.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

1. (201) What do we call the two rings that are made of steel wire and encased in rubber that hold the tire sidewalls against the wheel rim?
   a. Treads.
   b. Liners.
   c. Beads.
   d. Belts.

2. (201) What type of tire has plies running straight across from bead to bead, with stabilizer belts directly beneath the tread?
   a. Bias ply.
   b. Radial ply.
   c. Foam filled.
   d. Solid rubber.

3. (201) On a P-metric tire, the letter "P" indicates the
   a. pressure rating.
   b. load rating for the tire.
   c. tire is designed for a passenger car.
   d. tire is designed for off-road vehicles.

4. (201) When determining the aspect ratio of a tire, as the number becomes smaller, the tire size becomes
   a. thinner and shorter.
   b. wider and shorter.
   c. thinner and taller.
   d. wider and taller.

5. (201) Tread wear is given as a number between 100–500, with a higher numbered tire indicating
   a. more resistance to wear.
   b. less resistance to wear.
   c. tread design.
   d. tread depth.

6. (201) A rim with small ridges that hold the tire beads on the wheel during a blowout is called a
   a. safety rim.
   b. mag wheel.
   c. self-sealing rim.
   d. drop-center wheel.

7. (201) What component is *not* part of a three-piece wheel assembly?
   a. Continuous side ring.
   b. A rim housing.
   c. Split lock ring.
   d. Split side ring.

8. (201) In an effort to prevent mismatched rim components, Federal law requires the
   a. rim and wheel assembly easily fit together.
   b. rim size and type be stamped on wheel and rim components.
   c. split rim bolt head be flat to prevent accidental wheel removal.
   d. split ring and side lock be removable only for tire replacement.

9. (202) Tire tread is considered worn and could be unsafe when it measures less than
   a. 1/2”.
   b. 1/4”.
   c. 1/8”.
   d. 1/16”.

10. (202) Each of the following may result from an underinflated tire except
    a. loss of fuel economy.
    b. rapid tread wear.
    c. ply separation.
    d. a rough ride.

11. (202) Which type of tool scan is used to measure tire and wheel runout if you suspect a minor runout problem?
    a. Plumb-bob.
    b. Micrometer.
    c. Dial indicator.
    d. Vernier caliper.

12. (202) What type of balance will a bubble balancer provide to a wheel and tire assembly?
    a. Static.
    b. Dynamic.
    c. Wheel hop.
    d. Wheel shimmy.

13. (202) You should *never* attempt to repair tires with punctures larger than
    a. 1/4”.
    b. 1/2”.
    c. 3/4”.
    d. 1”.

14. (202) If a tire in a direct tire pressure monitoring system has low air pressure, but the system does *not* activate, what should you suspect first?
    a. Wiring.
    b. Sensors.
    c. Receiver.
    d. Warning light.

15. (202) Which tool should you use to remove a tapered roller wheel bearing race from the hub assembly?
    a. Pry bar.
    b. Air chisel.
    c. Screwdriver.
    d. Large drift punch.

16. (202) Which piece of equipment can help prevent back injuries when used to remove a heavy and awkward shaped wheel and tire assembly?
    a. Cherry picker.
    b. Wheel dolly.
    c. Floor jack.
    d. Winch.

17. (202) If a machine is unavailable, what can you use to break the bead on a large single-piece wheel and tire assembly?
    a. Sledge hammer.
    b. Pneumatic gun.
    c. Slide hammer.
    d. Forklift tines.

18. (202) What can you do to repair a rim that has lost some metal thickness in the side ring's mating areas?
    a. Weld a new bead of metal on the dilapidated area.
    b. Use an epoxy compound to repair the area.
    c. Nothing because the ring must be replaced.
    d. Braze the area, then sand to finish.

19. (202) When replacing a faulty rim component, how can you ensure it will not be mistakenly reused?
    a. Document the bad rim component in the motor safety computer database.
    b. Destroy the faulty component by cutting it with a torch.
    c. Paint it red to show that it is a faulty component.
    d. Mark it as bad and throw it in scrap metal.

20. (202) Initially inflating a heavy-duty rebuilt wheel and tire assembly to approximately 15 pounds per square inch (psi) with the valve removed and the tire in the cage,
    a. provides maximum pressure that the gauges in a tire cage will allow.
    b. allows a tube-type tire to overstretch the tube and flap.
    c. permits checking for proper component seating.
    d. purges any lubricants used to install the tire.

Student Notes

Please read the unit menu for unit 2 and continue ➔

Unit 2. Suspension Systems

THE SUSPENSION SYSTEM affects the way a vehicle handles on turns, what the vehicle occupants feel driving over rough terrain, and can prevent wear and tear on components by absorbing road shock. The following lessons will provide you greater understanding of how suspension systems work, as well as how to inspect and maintain them.

Suspension systems work with a vehicle's tires, frame, brakes, and steering systems in order to provide optimal performance. An engine can have plenty of horsepower, but a good suspension system makes for a better performing ride.

203. Suspension system technology

In this lesson, you will learn about the important functions of suspension system, and become familiar with the common components of different types of suspension systems. Please refer to *Modern Automotive Technology, 9th Edition* and the following table for the assigned reading, as well as review and ASE-type questions.

Assigned Material		
Task	**Material**	**Pages**
Read	Chapter 75: Suspension System Technology	1491–1510
Answer	Review Questions: 1, 2, 3, 6, 7, 8, 9, 11	1511
Answer	ASE-Type Questions: 5, 6, 11, 14	1511–1512

204. Suspension system diagnosis and repair

Even during the best of circumstances, vehicle suspension systems work very hard to absorb road shock and prevent the vehicle occupants from experiencing it. Over time, this constant abuse can result in significant wear and tear on suspension components. In this lesson, you will learn common procedures for inspecting and repairing suspension systems.

This lesson is broken up into two parts. The first includes the assigned reading in the textbook *Modern Automotive Technology, 9th Edition*, along with review, as well as review and ASE-type questions. The second part of the lesson consists of reading within this unit, along with self-test questions within this unit. In both cases, you will find the correct responses at the end of the unit.

To begin the lesson, please refer to *Modern Automotive Technology, 9th Edition* and the following table for the assigned reading and questions.

Assigned Material		
Task	**Material**	**Pages**
Read	Chapter 76: Suspension System Diagnosis and Repair	1513–1533
Answer	Review Questions: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	1533
Answer	ASE-Type Questions: 1, 5, 7, 9, 13	1534–1535

King pins

There is one final suspension component you should know how to remove and install. Since king pins are commonly found on larger trucks and other heavy-duty vehicles, they are not adequately covered in our *Modern Automotive Technology* textbook. King pins are used as a pivoting connection between the steering knuckle and a beam axle (fig. 2–1).

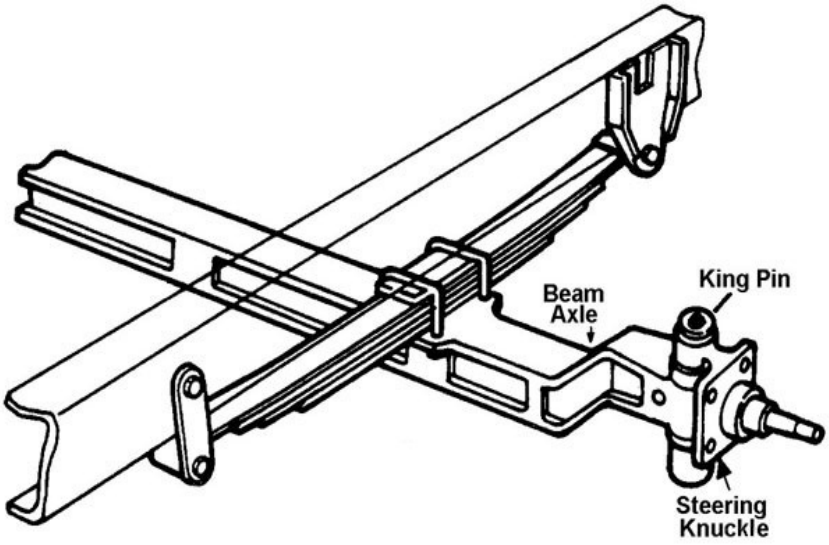

Figure 2–1. King pin location.

King pins are inspected in much the same way as ball joints; for example, if there is too much play between the knuckle and axle, the king pin must be replaced. To replace the king pin (fig. 2–2), perform the steps in the following table:

Step	King Pin Replacement Procedures
1.	Remove the wheel, brake drum, backing plate, and any steering arms as necessary.
2.	Remove the nut or clip which holds the locking pin in place and drive the pin out with a soft hammer.
3.	Remove the end caps.
4.	Drive the king pin from the steering knuckle and axle using a heavy hammer and a large brass drift. It is common for a king pin to be “frozen” in the axle. If this is the case, here are some recommended tips to help you get the king pin out: • Use a good penetrating solution generously between the king pin, knuckle, and axle. Hammer the axle beam several times in the area where the king pin fits. This action will loosen rust and binding in the beam. • Use a special king pin press. Your shop may have special equipment to make king pin removal much easier. If your shop does not have the equipment, you may be able to rig up your own “press” using a 10-ton floor jack and a heavy-duty chain. **CAUTION:** Do not apply heat to try to get a frozen king pin out. Heat can weaken the temper and integrity of the axle beam. In addition, some manufacturers use nylon bushings in the knuckle. Heat would melt the bushings, possibly making king pin removal more difficult.
5.	Reinstall the king pin and components in reverse order of removal, checking the front-end alignment as necessary.

While the preceding table covers the basic procedures for a typical king pin replacement, make sure you follow exact procedures in the correct service manual for the vehicle you are working.

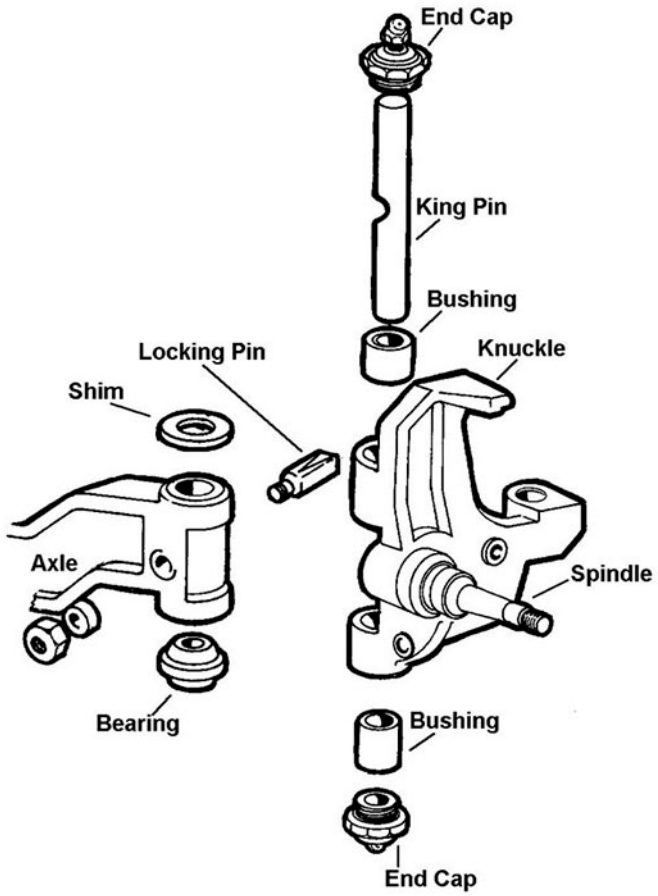

Figure 2–2. King pin configuration.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

204. Suspension system diagnosis and repair

1. During king pin removal, why is it a good idea to hammer the area where the king pin fits in the axle beam?

2. Why should you not use heat to remove a “frozen” king pin?

Answers to Textbook Questions

203

Chapter 75 Review Questions

1. (1) Supports the weight of the frame, body, engine, transmission, drive train, and passengers.
   (2) Provides a smooth ride by allowing the wheels and tires to move up and down with minimal body movement.

(3) Allows fast cornering without extreme body roll.
(4) Keeps tires in firm contact with road.
(5) Prevents excessive body squat when accelerating or heavily loaded.
(6) Prevents excessive body dive when braking.
(7) Allows front wheels to turn from side to side for steering.
(8) Works with steering system to help keep wheels in correct alignment.

2. (1) Control arm—A movable lever that fastens steering knuckle to vehicle's body or frame.
(2) Steering knuckle—Provides a spindle or bearing support for wheel hub, bearings, and wheel assembly.
(3) Ball joint—A movable connection that allows control arm to move up and down while allowing steering knuckle to swivel from side to side.
(4) Suspension spring—It supports vehicle weight and permits the control arm and wheel to move up and down.
(5) Shock absorber or damper—It helps keep the suspension from continuing to bounce after spring compression and extension.
(6) Control arm bushing—A sleeve that allows the control arm to swing up and down on the frame.

3. Independent.

6. Condition that causes the rear leaf springs to flex when driving or braking forces are applied to the suspension system.

7. Up-and-down movement of the suspension system twists the torsion bar. It will then try to return to its original shape, moving the control arm back into place.

8. Unsprung.

9. False.

11. Shock absorbers limit spring oscillations to smooth the vehicle's ride. While most shocks are filled with oil, some shocks are filled with air, gas and oil. When the shocks are compressed or extended, the oil causes resistance to movement. A shock is connected to a suspension component and to the vehicle's body or frame, allowing the rod to be pulled in and out to resist suspension system movements.

Chapter 75 ASE-Type Questions

5. (B) B only.

6. (C) Both A and B.

11. (A) A only.

14. (A) A only.

204

Chapter 76 Review Questions

1. Abnormal noises, tire wear, steering wheel pull, front end shimmy.

2. (C) Both A and B.

3. Spring fatigue allows a vehicle's body to settle toward the axles, lowering vehicle height. This changes the position of the control arms, resulting in misaligned wheels. This condition also affects the ride and appearance of the vehicle.

4. Curb height is the distance from a point on the vehicle to the ground. Curb weight is generally the weight of the vehicle with a full tank of fuel and no passengers or luggage.

5. Coil spring compressor.

6. A compressed coil spring has a tremendous amount of stored energy. If the spring is not compressed, the lower control arm and the spring could shoot downward with deadly force when the ball joint is unbolted.

7. Fork, ball joint separator.

8. By using a ball joint wear indicator or jacking up the vehicle and physically moving the control arm and joint.

9. Basically, strut removal involves unbolting the steering knuckle (front) or bearing support (rear), the brake lines, and the upper strut assembly-to-body fasteners.

10. (D) Air chisel.

Chapter 76 ASE-Type Questions

1. (C) Both A and B.
5. (B) B only.
7. (B) B only.
9. (A) A only.
13. (C) Both A and B.

Answers to Self-Test Questions

204

1. To loosen rust and binding in the beam.
2. Heat can weaken the temper and integrity of the axle. It can also melt the nylon bushings, possibly making the king pin removal more difficult.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to AFCDA.

21. (203) The component that allows a leaf spring to change length when bent is
    a. a shock absorber.
    b. an insulator.
    c. a shackle.
    d. an U-bolt.

22. (203) When the wheels move up and down in a torsion bar suspension system, the torsion bar moves in a
    a. forward motion.
    b. twisting motion.
    c. rearward motion.
    d. sideways motion.

23. (203) What prevents the vehicle from continuing to bounce after striking a dip or hump?
    a. Self-leveling sway bar.
    b. Shock absorber.
    c. Torsion link.
    d. Coil spring.

24. (203) What purpose does the nitrogen gas in a gas-charged shock absorber serve?
    a. Cools the oil.
    b. Replaces the oil.
    c. Prevents bubbles.
    d. Suspends contaminants.

25. (203) In the vehicle suspension system, the stabilizer bar
    a. fastens to the lower and upper control arms as well as to the frame.
    b. fastens to both lower control arms and to the frame.
    c. is only linked to the lower and upper control arms.
    d. is only linked to both lower control arms.

26. (203) The track rod is used on rear suspension systems of some vehicles to prevent axle movement
    a. upward.
    b. downward.
    c. from side-to-side.
    d. from front-to-rear.

27. (203) In a modified MacPherson strut front suspension system, the coil spring is mounted
    a. over the top of the strut.
    b. around the strut damper.
    c. on top of the lower control arm.
    d. between the upper control arm and frame.

28. (203) Which type of suspension leveling system incorporates air shocks, a height sensor, and a compressor?
    a. Manual.
    b. Automatic.
    c. Twin I-beam.
    d. Short-and-long-arm.

29. (203) Which sensor is *not* part of a typical electronic suspension system?
    a. Acceleration sensor.
    b. Steering sensor.
    c. Height sensor.
    d. Brake sensor.

30. (204) When performing a shock absorber bounce test, if the shocks are still good, the body should
    a. not bounce at all.
    b. rebound only once or twice.
    c. rebound three to four times.
    d. rebound according to the shocks' rating.

31. (204) Which type of action should be taken if you notice oily wetness on a shock absorber?
    a. Wipe the shock clean; a little seepage is normal.
    b. Check the oil level of the shock.
    c. Replace the shock oil seal.
    d. Replace the shock.

32. (204) How can you check the condition of a suspension spring?
    a. Perform a spring run out test.
    b. Check the ball joints for play.
    c. Measure the vehicle curb height.
    d. Remove the U-bolts to relieve spring tension.

33. (204) When greasing ball joints with rubber seals, you know there is enough grease in the boot when
    a. the seal bulges slightly.
    b. a small amount of grease leaks out from the seal.
    c. the old grease is pushed out and is replaced by the new grease.
    d. you have squirted four pumps from a grease gun into the grease fitting.

34. (204) How can you check a ball joint for wear besides using a ball joint wear indicator?
    a. Check the torque on the fasteners.
    b. Turn the steering wheel back and forth briskly.
    c. Push on the grease boot with your thumb and forefinger.
    d. Use a long steel pry bar to wiggle the tire up and down and sideways.

35. (204) Which method is *not* approved for connecting ball joints?
    a. Bolting.
    b. Welding.
    c. Riveting.
    d. Pressing.

36. (204) Check for bushing wear by
    a. measuring the bushing with a dial indicator.
    b. measuring the bushing with a scale.
    c. counting the number of times the vehicle bounces.
    d. moving the control arm against its normal movement.

37. (204) The *most* common trouble experienced with a MacPherson strut suspension is
    a. bent spindles.
    b. loose rod nuts.
    c. sagging strut coil springs.
    d. worn strut shock absorbers.

Please read the unit menu for unit 3 and continue ➔

Unit 3. Steering and Alignment

THE STEERING AND ALIGNMENT SYSTEMS are important systems in providing the safe operation of any vehicle. A vehicle would not be very effective if there were no means to control its direction of travel or if it were to veer on its own during travel. This unit will cover steering and alignment fundamentals, as well as proper diagnosis and repair procedures you are likely to use on vehicles in the Air Force fleet.

3–1. Steering Systems

You will begin by learning about the steering system fundamentals, then move on to steering system diagnosis and repair.

205. Steering system technology

In this lesson, we will cover steering system functions, different steering system types, and the key components that make them work. Please refer to *Modern Automotive Technology, 9th Edition* and the following table for the assigned reading, as well as review and ASE-type questions.

Assigned Material		
Task	**Material**	**Pages**
Read	Chapter 77: Steering System Technology	1537–1557
Answer	Review Questions: 1, 2, 4, 8, 11, 12, 14	1557–1558
Answer	ASE-Type Questions: 4, 9, 10, 11, 14	1558–1559

206. Steering system diagnosis and repair

With an understanding of steering system technology, we can now discuss repair procedures that will ensure a vehicle's safe and efficient operation. Please refer to *Modern Automotive Technology, 9th Edition* and the following table for the assigned reading, as well as review and ASE-type questions.

Assigned Material		
Task	**Material**	**Pages**
Read	Chapter 78: Steering System Diagnosis and Repair	1561–1574
Answer	Review Questions: 1, 2, 4, 5, 7, 8	1575
Answer	ASE-Type Questions: 1, 2, 5, 7, 12, 14	1575–1576

3–2. Vehicle Wheel Alignment

Proper wheel alignment maximizes operational safety, fuel economy, and tire life. Maintaining good alignment will help to avoid costly accelerated wear and tear on a vehicle.

207. Wheel alignment

In this lesson, you will learn about the basic principles of wheel alignment, key terms, and alignment procedures. Please refer to *Modern Automotive Technology, 9th Edition* and the following table for the assigned reading, as well as review and ASE-type questions.

Assigned Material		
Task	**Material**	**Pages**
Read	Chapter 79: Wheel Alignment	1581–1597
Answer	Review Questions: 1, 3, 4, 5, 6, 7, 8, 9, 12, 14, 17	1598
Answer	ASE-Type Questions: 3, 4, 5, 6, 9, 11, 14	1598–1599

Answers to Textbook Questions

205

Chapter 77 Review Questions

1. (1) Provide precise control of the front-wheel direction and, sometimes, the rear wheel direction.
   (2) Maintain the correct amount of effort needed to turn the wheels.
   (3) Transmit road feel to the driver's hands.
   (4) Absorb most of the shock going to the steering wheel as the tires hit bumps and holes in the road.
   (5) Allow for suspension action.
2. (1) Steering wheel—It is used by the driver to rotate a steering shaft that passes through the steering column and firewall.
   (2) Steering shaft—A long steel shaft that transfers turning motion from steering wheel to steering gearbox.
   (3) Steering column—A hollow tube that supports steering wheel and steering shaft.
   (4) Steering gearbox—It changes turning motion into straight-line motion (from left or right) for moving steering knuckles.
   (5) Steering linkage—It connects steering gearbox to steering knuckles and wheels.
   (6) Ball sockets—They are grease-filled swivel joints on the tie-rod ends that allow linkage arms to swivel up and down (for suspension action) and from left to right (for turning).
4. (1) Steering pinion gear—A small gear rotated by steering wheel and steering shaft, with teeth that mesh with the teeth on the rack.
   (2) Rack—A long steel bar with teeth along one section that slides sideways in its housing as the pinion gear turns.
   (3) Gear housing—It holds pinion gear and the rack.
   (4) Tie-rods—They are steel rods with swivel sockets on each end that connect the rack with two front steering knuckles.
8. False.
11. Pump, hydraulic.
12. True.
14. (1) Power cylinder—A hydraulic cylinder machined inside the rack or gear housing.
   (2) Power piston—A hydraulic, double-acting piston formed on the rack shaft.
   (3) Hydraulic lines—Steel tubing connecting control valve and power cylinder.
   (4) Control valve—A rotary valve or spool valve that regulates pressure entry into each end of power cylinder.

Chapter 77 ASE-Type Questions

4. (B) Steering rack.
9. (B) B only.
10. (C) Both A and B.
11. (B) B only.
14. (C) Both A and B.

206

Chapter 78 Review Questions

1. (A) 1 ½ inch (38 mm).
2. With the full weight of the vehicle on the wheels, ask someone to rock the steering wheel back and forth while you look for looseness in the steering system.
4. (B) Broken condenser.
5. (D) All of the above
7. (D) 1000 psi (6895 kPa).
8. True.

Chapter 78 ASE-Type Questions

1. (C) Both A and B.
2. (B) B only.
5. (B) B only.
7. (A) A only.
12. (A) A only.
14. (B) B only.

207

Chapter 79 Review Questions

1. To position in a straight line.
3. Caster.
4. (1) To aid directional control of the vehicle.
   (2) To cause the wheels to return to the straight-ahead position.
   (3) To offset road crown pull (steering wheel pull caused by hump in center of road).
5. Positive caster tilts the top of the steering knuckle toward the rear of the vehicle and helps keep the vehicle's wheels traveling in a straight line. Negative caster is the opposite of positive caster. It tilts the top of the steering knuckle toward the front of the vehicle.
6. (D) All of the above.
7. Camber.
8. (1) Prevent tire wear on the outer or inner tread.
   (2) Load the larger inner wheel bearing.
   (3) Aid in steering by placing vehicle weight on the inner end of the spindle.
9. With positive camber, the tops of the wheels tilt outward when viewed from the front of the vehicle. With negative camber, the tops of the wheels tilt inward when viewed from the front.
12. Toe-in is produced when the wheels are closer at the front than at the rear. Toe-in causes the wheels to point inward at the front. Toe-out results when the wheels are farther apart at the front than at the rear. Toe-out causes the front of the wheels to point away from each other.
14. The position or direction of the two front wheels in relation to the two rear wheels.
17. The following in order:
   (1) Inspect and correct tire, steering, and suspension problems.
   (2) Adjust caster.

(3) Adjust camber and recheck caster.
(4) Adjust toe.
(5) Check toe-out in turns (needed if there is damage).
(6) Check caster, camber, and toe on rear wheels (if needed).
(7) Check tracking (if needed).

Chapter 79 ASE-Type Questions

3. (A) A only.
4. (A) A only.
5. (A) A only.
6. (A) A only.
9. (A) A only.
11. (A) A only.
14. (A) A only.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to AFCDA.

38. (205) The shape of the rack in a rack-and-pinion steering system is a
    a. long bar.
    b. helical.
    c. round.
    d. bevel.

39. (205) Which part is *not* a part in a recirculating-ball steering gearbox?
    a. Universal joint.
    b. Sector shaft.
    c. Worm shaft.
    d. Ball nut.

40. (205) Where are the ball bearings located in a manual recirculating ball steering gear?
    a. Inside the worm shaft.
    b. Inside the sector shaft.
    c. In the grooves in the worm gear.
    d. Between the ball nut and the sector shaft.

41. (205) What part is the outer tie-rod connected to in a linkage steering system?
    a. An idler arm.
    b. A center link.
    c. A worm shaft.
    d. A steering knuckle.

42. (205) A power rack-and-pinion assembly normally does not consist of
    a. a power cylinder.
    b. a control valve.
    c. a power piston.
    d. an accumulator.

43. (205) In an electronic steering assist system, a small electric motor may *not* be mounted
    a. on the inner tie rod.
    b. on the steering column.
    c. inside the rack housing.
    d. inside the steering wheel.

44. (205) A four-wheel steering system cannot be
    a. mechanical.
    b. electronic.
    c. hydraulic.
    d. manual.

45. (206) Excessive steering wheel play can be seen by no front wheel movement when turning the steering wheel by more than
    a. 1/4”.
    b. 3/4”.
    c. 1 1/4”.
    d. 1 1/2”.

46. (206) Steering system noise may be caused by all of the following problems *except*
    a. a loose or slipping belt.
    b. overinflated front tires.
    c. unlubricated ball sockets.
    d. low power steering fluid level.

47. (206) Which tool can be used to remove a steering wheel from the steering shaft?
    a. Rubber mallet.
    b. Slide hammer.
    c. Wheel puller.
    d. Pry bar.

48. (206) What should you do to make sure the front-end alignment will *not* be disturbed before removing a tie-rod end?
    a. Count the number of turns to remove the tie-rod end or measure or mark the tie-rod end length.
    b. Count the number of exposed threads on the center link and pitman arm to the tie-rod end.
    c. Measure the distance between the front tires from the front of the tire.
    d. Measure the distance between the front tires from the rear of the tire.

49. (206) Power steering pump pressure, measured in pounds per square inch (psi), can exceed
    a. 10,000 psi.
    b. 5,000 psi.
    c. 2,500 psi.
    d. 1,000 psi.

50. (206) When installing a new power steering pump hose, start the new hose fittings by hand to prevent
    a. cross contamination.
    b. cross threading.
    c. O-ring damage.
    d. hose twisting.

51. (206) After servicing hydraulic components, how can you bleed a power steering system?
    a. Use the bleeder screw found on the reservoir.
    b. Start the engine and turn the steering wheel fully from side to side.
    c. Loosen the pressure line slightly and retighten after the bubbles stop.
    d. Allow the vehicle to idle with the power steering cap removed for at least three minutes.

52. (207) How many fundamental angles or specifications are involved in a wheel alignment?
    a. 3.
    b. 4.
    c. 5.
    d. 6.

53. (207) Which wheel alignment measurement results when the wheels are farther apart at the front than at the rear?
    a. Toe-in.
    b. Toe-out.
    c. Camber.
    d. Radius angle.

54. (207) Excessive setback is usually the result of
    a. worn tires.
    b. bad ball joints.
    c. collision damage.
    d. worn wheel bearings.

55. (207) Which wheel alignment angle or specification refers to the position or direction of the two front wheels in relation to the two rear wheels?
    a. Setback.
    b. Tracking.
    c. Turning radius.
    d. Steering axis inclination.

56. (207) The three commonly adjustable wheel alignment angles do *not* include
    a. tracking.
    b. camber.
    c. caster.
    d. toe.

Student Notes

Please read the unit menu for unit 4 and continue ➔

Unit 4. Brakes and Control Systems

ALL VEHICLES MUST HAVE a means of bringing their thousands of pounds of metal, plastic, and other materials to a controlled stop quickly, safely, and reliably. In this final unit, we will discuss brakes and control systems, beginning with hydraulic brake and hybrid brake system technologies, along with proper diagnosis, service and maintenance, and repair. Since we will cover air brakes in the next volume, pay close attention; you will come to find that hydraulic and air brakes share many of the same basic operating principles. After learning about brake technology and service, we will discuss advanced braking and control systems, including anti-lock brake systems, traction control, and stability control. We will end the unit with a discussion of self-contained braking systems, usually found on trailers rather than vehicles.

4–1. Hydraulic and Hybrid Brake Systems

Most passenger and light-duty vehicles, along with some medium-duty trucks, use hydraulic brakes today. For this reason, you will likely find yourself servicing a hydraulic brake system in the course of your Air Force duties as a vehicle maintenance technician. As hybrids become more prevalent in our fleet, it will also be important to understand how their regenerative braking systems cooperate with their standard hydraulic brake systems. In this section, you will learn about these systems, including their operation and effective maintenance, service, and repair.

208. Brake system technology

This lesson will teach you the fundamentals of hydraulic brake systems, to include drum and disc brakes, before briefly discussing hybrid-braking systems. This lesson will provide you an understanding of how braking systems work and prepare you for the next lesson. Please refer to *Modern Automotive Technology, 9th Edition* and the following table for the assigned reading, as well as review and ASE-type questions.

Assigned Material		
Task	**Material**	**Pages**
Read	Chapter 80: Brake System Technology	1601–1622
Answer	Review Questions: 1, 2, 4, 5, 6, 8, 10, 12, 13, 15, 17, 18, 19	1623
Answer	ASE-Type Questions: 1, 2, 5, 7, 10, 11, 13	1623–1624

209. Brake system diagnosis, service, and repair

In this lesson, you will take the fundamentals you learned about braking systems, and apply them to learning how to diagnose, service, and repair hydraulic brakes. Developing this skillset is critical to ensure the safety of your fellow Airmen as they operate our vehicles in performance of their duties. Please refer to *Modern Automotive Technology, 9th Edition* and the following table for the assigned reading, as well as review and ASE-type questions.

Assigned Material		
Task	**Material**	**Pages**
Read	Chapter 81: Brake System Diagnosis, Service, and Repair	1625–1650
Answer	Review Questions: 1, 2, 3, 6, 8, 9, 10, 13, 14, 15, 18, 20	1651
Answer	ASE-Type Questions: 1, 3, 6, 7, 11, 13, 14, 15	1651–1652

4–2. Advanced Braking and Control Systems

Over the years, as vehicles have become more advanced, engineers have capitalized on technology to increase vehicle safety. This section will introduce you to these advanced systems. For example, anti-lock brake systems were once considered luxuries, but are now standard equipment on new vehicles. Traction and stability control systems were later developed to further increase the safety of vehicle occupants.

210. Anti-lock brakes, traction, and stability control

Anti-lock brakes, traction control, and stability control are just a few of the advanced systems helping to protect occupants in modern vehicles. This lesson will teach you the fundamentals of these systems, before discussing how to diagnose and repair them. Please refer to *Modern Automotive Technology, 9th Edition* and the following table for the assigned reading, as well as review and ASE-type questions.

Assigned Material		
Task	**Material**	**Pages**
Read	Chapter 82: Anti-Lock Brakes, Traction, and Stability Control	1653–1670
Answer	Review Questions: 1, 2, 3, 4, 5, 7, 8	1670–1671
Answer	ASE-Type Questions: 2, 3, 6, 7, 8	1671

4–3. Self-Contained Braking Systems

Self-contained braking systems typically found on smaller trailers are meant to be towed by passenger cars, pickups, and vans. Oftentimes, these systems are electric, but we will also discuss a couple of other ways a trailer's speed may be controlled. This section will introduce you to these types of braking components

211. Self-contained brake system fundamentals

The brakes explained in this lesson are found mainly on trailers and are designed to aid the operator with slowing or stopping the vehicle. They also help keep the trailer under control during operation, and provide a means of stopping the trailer if it breaks away from the tow vehicle.

Regulations and fundamental operation

Federal traffic safety law specifies all trailers that require brakes shall have a means of activating the trailer brakes under trailer breakaway conditions. In a hydraulic surge brake system, activating the trailer brakes is normally accomplished by means of a cable or chain connected to the tow vehicle. Under trailer breakaway conditions, this connecting linkage provides a mechanical activation of the master cylinder to maintain brake system operation as the trailer stops.

If the trailer has an electric brake system, emergency breakaway regulations require the trailer be equipped with an emergency battery backup system. It will provide electrical power to the brake magnets during the trailer breakaway brake activation process. In an electric breakaway system, there is a breakaway switch with a pull pin and cable.

When attached to the tow vehicle, the breakaway switch will provide an electrical activation of the trailer brakes if the trailer disconnects from the tow vehicle during travel. Normally packaged as an emergency breakaway kit, the components include a battery and charger, an emergency switch, and a battery case in one package.

Hydraulic drum (surge) brake system

Trailer hydraulic drum brake systems (also known as surge brakes) can be installed on a wide variety of axle capacities, including most boat, utility, and recreational vehicle trailer applications.

Hydraulic surge brakes are completely self-contained trailer braking systems, requiring no electrical, hydraulic, or other connection of brake sensing components to the tow vehicle for automatic operation of the trailer brakes. In a hydraulic surge brake system, inertial differential pressure develops between the tow vehicle and the trailer during the braking process. This creates a mechanical pressure applied to the push rod of the master cylinder in the hydraulic surge brake coupler. This mechanical pressure is proportional to the difference in pressure between the two vehicles. Therefore, the hydraulic output of the brake coupler and resulting brake operation is automatically regulated and proportional to the amount of braking applied to the tow vehicle.

In other words, as the brakes on the towing vehicle are applied, the momentum of the trailer pushes the master cylinder's pushrod in, which begins to apply the trailer brakes. The harder the tow vehicle's brakes are applied, the more pressure is applied to the surge brake master cylinder, resulting in more braking force being applied to the trailer brakes. As the speed of the vehicle and trailer equalize, less force is applied to the trailer's master cylinder until the trailer matches speed with the tow vehicle. Conversely, as the vehicle speeds up, any pressure on the trailer's master cylinder is relieved until the brakes are fully released and the trailer wheels can spin freely.

The vast majority of trailer hydraulic surge brake systems are packaged with drum brakes; however, they can be used with disc brakes with equal effectiveness. Both systems have unique design, installation, and maintenance considerations.

The hydraulic surge brake coupler does an excellent job of providing automatic proportional braking response while towing. However, it cannot distinguish between braking while towing and the mechanical differential pressure created between the tow vehicle and trailer while backing up. This requires a method of deactivating the brakes while backing up. A reverse solenoid is wired to the tow vehicle's backup lights to vent brake pressure when backing up. The solenoid activates when provided the backup light signal, and deactivates with the removal of the signal. When the solenoid deactivates, the surge brake system reverts to normal operation.

CAUTION: Never mechanically lock out the brake coupler! This could lead to a non-operating brake system if you forget to remove the lockout pin.

Free backing brakes

Free backing brakes, on the other hand, automatically disengage while backing up. The reverse rotation of the wheel triggers activation of components internal to the individual brake clusters that deactivates the brakes while backing up. The brakes then re-engage for normal operation when the wheel turns forward. This is why free backing brakes are normally the brakes of choice in a hydraulic drum brake system. To combat corrosion, these brake clusters are now available with hot dip galvanized backing plates and stainless steel brake springs, and can easily be fitted with a freshwater wash down kit to purge salt and dirt from the brake interior.

Both hydraulic drum brakes and hydraulic disc brakes used in trailer braking systems operate with the same principal as their standard automotive cousins. In a drum brake system, the wheel cylinder push rod pushes out, engaging the brake shoes to the interior of the hub drum braking surface. With disc brakes, the calipers compress the brake pads onto the brake rotor surface. As described in the hydraulic drum brake system, hydraulic surge brake coupler can activate both types of brakes.

The primary difference in their operation results from their construction; for example, hydraulic drum brakes can be manufactured with free backing components integral to the brake cluster. This in turn automatically deactivates the brakes while the trailer backs up. On the other hand, disc brakes require the installation of a backing kit to deactivate the trailer brakes while backing up. In disc brake systems, it may also be necessary to remove the hydraulic return flow restrictions present in most brake couplers.

In a drum brake system, the shoe return spring pulls the wheel cylinder push rod in. The master cylinder return spring also pulls, creating a strong differential pressure. This pressure is for the brake fluid return from the wheel cylinder to the master cylinder upon release of braking pressure from the master cylinder push rod. However, in a disc brake system, only the master cylinder return spring provides a pull return for brake fluid when the brakes are released.

For this reason, it is essential to remove all check valve and other restrictions that would inhibit the return flow of fluid back to the master cylinder. If they are left in place, the brake calipers can remain locked or dragging, and may not allow the brakes to release as you attempt to pull forward.

Electric brakes

Utility and recreational vehicle trailers commonly use electric brakes. When installed, wired, and maintained properly, their painted automotive grade components provide excellent service in this application.

Electric brakes do not hold up well in wet environments. Some common reasons for electric brake failure include the following:

- Deterioration of painted automotive grade brake springs.
- Adhesively bonded shoe pads become detached from their foundation plates.
- Corrosion due to water-soaked magnet electrical insulation.

NOTE: Due to the common reasons for the failure of electric brakes, most boat trailer owners opt for either disc or drum hydraulic surge brakes.

Electric brakes require a brake controller to apply power to the brake system. With electric brakes, as power is applied to the electromagnets in the brake cluster, the magnets are pulled to the interior flat surface of the hub drum. As the wheel and drum turn during highway travel, this attraction of the magnet to the flat drum face pulls the lever arm of the brake-actuating cam. This, in turn, rotates the cam and forces the brake shoes out to contact the drum braking surface. The more power applied to the magnets, the greater the advantage on the cam, resulting in greater braking response.

Most electric brake controllers are dash-mounted, allowing the driver access to the manual override button. The manual override button allows the driver to activate the trailer brakes without operating the tow vehicle braking system. This can be important if your trailer is prone to sway. By bumping the electric brakes on the trailer during sway, the driver can dampen and control sway problems should they occur.

One negative feature of electric brakes is, if you use a dash-mounted brake controller, you must have a controller on every vehicle with which you tow the electric brake-equipped trailer.

Electric brake controllers types

Electric brake controllers come in a variety of styles, including the following, which are also the most common:

- Power-only adjustment.
- Dash-mounted inertial deceleration.
- Trailer-mounted inertial deceleration.
- Hydraulic over electric.

As with most mechanical devices, many times the simplest system works the best.

Power-only adjustment controllers

These controllers are dash-mounted and have a simple adjustment that allows the driver to adjust the brake power output dependent upon the load on the trailer. For example, a flatbed equipment trailer is being towed with nothing on the trailer bed and the trailer brakes are locking up. The driver moves the adjustment bar down to a point just below where the brakes lock up. This is the proper controller set point for that load. Later, the driver loads a tractor onto the trailer and readjusts power upward to a point just short of brake lockup. If a travel trailer is the towed load, the adjustment need only be made one time. These controllers apply current to the magnets in a power ramp cycle. Some controllers have this time ramp preprogrammed; other controllers allow a user adjustment of the time cycle. These controllers are not position sensitive and can be mounted at any angle. These are the simplest and most economical controllers, and many times work better than other types.

Dash-mounted inertial deceleration controllers

These controllers normally contain an inertial mass attached to a pendulum. As the tow vehicle brakes, the inertial mass swings the pendulum forward, providing a variable electrical output to the brake magnets and therefore providing a variable trailer braking response. These controllers are position sensitive; they must be either mounted level or the inertial mass device must be compensated for non-level installation. This compensation is accomplished by means of the sensor adjust control.

Power gain adjustments are also available on these controllers to compensate for varying load conditions, and they contain the manual bypass button discussed earlier.

Trailer-mounted inertial deceleration controllers

If you tow the same trailer with a variety of tow vehicles, these controllers can provide trailer self-contained brake system capability. They will still require battery power wiring from the tow vehicle to operate properly, but each vehicle will not need the conventional dash-mounted controller.

It is important to note these controllers must be positioned so the inertial mass sensor will swing forward during tow vehicle braking. In addition, the tow vehicle driver does not have manual override capability with these style units.

Hydraulic over electric controllers

These controllers connect into the brake line tubing of the tow vehicle. They each have a pressure sensor that determines the braking level to apply to tow vehicle brakes. The controllers then send proportional electrical power outputs to the trailer brake magnets. The pressure sensor on this type of controller requires a small amount of brake fluid from the tow vehicle brake system.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

211. Self-contained brake system fundamentals

1. What does Federal traffic safety law specify regarding trailer brakes?

2. How is the reverse solenoid activated?

3. What is meant by “free backing” brakes?

4. What are the most common reasons for electric brake failure?

5. List the most common types of electric brake controllers.

6. Explain how a dash-mounted inertial deceleration controller works.

Answers to Textbook Questions

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Chapter 80 Review Questions

1. (1) Brake pedal assembly—this is a foot lever for operating the master cylinder and power booster.
   (2) Master cylinder—A hydraulic-piston pump that develops pressure for the hydraulic brake system.
   (3) Brake booster—A vacuum, electric, or power steering-operated device that assists brake pedal application.
   (4) Brake lines and hoses—Metal tubing and rubber hose that transmit pressure to the wheel brake assemblies.
   (5) Wheel brake assemblies—Hydraulic-mechanical mechanisms that use hydraulic pressure to produce friction to slow or stop each wheel.
   (6) Emergency brakes (parking brakes)—Mechanical or electric systems for applying rear brake assemblies.
2. (1) Caliper—An assembly that holds a hydraulic cylinder, piston, seals, and brake pads.
   (2) Caliper cylinder—A machined hole in the caliper into which the piston fits.
   (3) Brake pads—Friction members that are pushed against the disc by the action of the master cylinder, caliper, and piston.
   (4) Brake disc—A large metal rotor that holds the wheel and tire and uses friction from the brake pads to stop or slow wheel rotation.
4. Hydraulic.
5. (1) It develops pressure, causing the wheel cylinder pistons to move toward the discs or drums.
   (2) After all the shoes or pads produce sufficient friction, it helps equalize the pressure required for braking.
   (3) It keeps the system full of fluid as the brake linings wear.
   (4) It can maintain a slight pressure to keep contaminants from entering the system.
6. For added safety.
8. Booster.
10. True.
12. The elastic action of the piston seal acts as a spring to retract the piston.
13. Floating and sliding calipers are used to avoid vibration problems.
15. The primary brake shoe is the front shoe. It normally has a slightly shorter lining. The secondary brake shoe is the rear shoe. It has the largest lining surface area.
17. To equalize braking action at each wheel during light brake applications.
18. Limits pressure at the rear drum brakes when high pressure is needed to apply the front disc brakes. Consequently, the proportioning valve prevents rear-wheel lockup during heavy brake application.
19. Single unit that functions as a brake warning light switch, a metering valve, and/or a proportioning valve.

Chapter 80 ASE-Type Questions

1. (D) Neither A nor B.
2. (A) A only.
5. (B) B only.
7. (A) A only.
10. (A) A only.
11. (C) Both A and B.
13. (C) Both A and B.

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Chapter 81 Review Questions

1. A warped disc or an out-of-round brake drum. Hard spots on the disc or drum can also cause vibration.
2. Grabbing.
3. Pulling.
6. (1) Metal-on-metal grinding—The sound occurs only when braking. It may be due to worn brake linings; the shoe or pad may be rubbing on the metal drum or brake disc.
   (2) Squeak—This may be caused by glazed brake linings. An unlubricated brake drum backing plate, foreign material embedded in the linings, or a wear indicator rubbing on a rotor.
   (3) Rattle—It may be due to a missing anti-rattle clip or disconnected spring on the brake caliper assembly. Loose or disconnected parts in the drum brake assembly can also cause a rattle from inside the brake assembly.
8. Brake fluid level should be 1/4” or 6 mm from the top of the master cylinder reservoir.
9. Remove one front wheel and one rear wheel. When inspecting the disc brakes, check the thickness of the brake pad linings. They should be replaced when the most worn part of the lining is no thicker than approximately 1/8” or 3 mm. When inspecting the drum brakes, remove the brake drum to expose the brake shoes, wheel cylinder, the braking surface of the drum, the adjuster mechanism, and other parts. The brake shoe linings must never be allowed to wear think than approximately 1/16” or 1.5 mm. The shoes should not be glazed or coated with brake fluid, grease or differential fluid. Any of these problems requires lining replacement. If contaminated, the cause must be corrected before replacing the linings.
10. Pump the brake pedal several times to remove any vacuum from booster. Then, press down lightly on the brake pedal as you start the engine. If the vacuum booster is functioning, the brake pedal will move downward slightly as soon as the engine starts.
13. Bench bled.
14. (1) Manual bleeding.
    (2) Pressure bleeding.
    (3) Vacuum bleeding.
15. (1) Replace worn brake pads.
    (2) Rebuild the caliper assembly.
    (3) Turn (machine) the brake discs.
    (4) Bleed the system.
18. (1) Remove parts from the backing plate.
    (2) Clean and inspect the parts.
    (3) Replace the brake shoes.
    (4) Replace or rebuild the wheel cylinders.
    (5) Turn (resurface) the brake drums.
    (6) Lubricate and reassemble the brake parts.
    (7) Preadjust, bleed, and test the brakes.

20. Fit a brake-adjusting gauge into the brake drum. Set gauge for the inside diameter of the drum. Tighten lock on the gauge. Fit the gauge over the brake shoes, and then turn the star wheel or move the adjuster arm until the linings touch the gauge. This will ensure that linings are the correct distance from the inside of the drum.

Chapter 81 ASE-Type Questions

1. (C) Both A and B.
3. (C) Both A and B.
6. (D) Neither A nor B.
7. (A) A only.
11. (A) A only.
13. (A) A only.
14. (B) B only.
15. (B) B only.

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Chapter 82 Review Questions

1. Anti-lock brake.
2. Braking distance can increase, and steering control can be lost.
3. (1) Wheel speed sensors—Magnetic pickups for detecting the rotating speed of each tire and wheel assembly.
   (2) ABS control module—A small computer, or processor, that uses sensor inputs to control electro-hydraulic modulator.
   (3) Electro-hydraulic modulator—A control module-operated solenoid valve and electric pump module that cycles pressure to each wheel brake cylinder if its speed begins to slow down too much, indicating tire skid or wheel lockup.
   (4) Hydraulic brake circuits or channels (ABS channel)—A circuit to feed ABS hydraulic brake pressure to wheel cylinders or caliper pistons.
4. Directional stability.
5. Signals.
7. (1) Brake fluid reservoir—A container for holding an extra supply of brake fluid.
   (2) Brake solenoid valve block—An electro-hydraulic device that contains coil-operated valves that control brake fluid flow to each wheel brake cylinder.
   (3) Brake accumulator—A chamber for storing extra brake fluid under high pressure.
   (4) Brake fluid pump and motor—A high-pressure pump operated by a small electric motor that provides brake fluid pressure for ABS system.
   (5) Brake pressure switch—A sensor that monitors brake fluid pressure and controls operation of the electric motor for the hydraulic pump.
   (6) Brake master cylinder booster assembly—A conventional master cylinder with power assist for operating brakes under normal conditions.
8. (1) Isolation mode—ABS control module detects that tire is starting to skid and energizes the modulator to isolate that hydraulic circuit from the other brake lines.
   (2) Dump mode—ABS releases hydraulic pressure to one or more of the brake wheel cylinders or calipers to stop tire skidding.
   (3) Reapply mode—ABS applies hydraulic pressure to one or more of the wheel brake assemblies to reapply the brakes during pressure modulation.

Chapter 82 ASE-Type Questions

2. (A) A only.
3. (C) Both A and B.
6. (A) A only.
7. (D) Neither A nor B.
8. (C) Both A and B.

Answers to Self-Test Questions

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1. All trailers that require brakes shall have a means of activating the trailer brakes under trailer breakaway conditions.
2. Wired to the tow vehicle's backup lights, the solenoid activates when the backup light signal is provided and deactivates when the signal is removed.
3. The brakes automatically disengage while backing.
4. Deterioration of painted automotive grade brake springs, adhesively bonded shoe pads become detached from their foundation plates, and corrosion due to water-soaked magnet electrical insulation.
5. Power-only adjustment, dash-mounted inertial deceleration, trailer mounted inertial deceleration, and hydraulic over electric.
6. The inertial mass swings the pendulum forward, providing a variable electrical output to the brakes.

Complete the unit review exercises.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to AFCDA.

57. (208) Which percentage (%) of braking power is typically handled by the front brakes?
    a. 30%–40%.
    b. 45%–55%.
    c. 60%–70%.
    d. 75%–85%.

58. (208) Which master cylinder component allows fluid to enter the rear of the cylinder as the piston slides forward?
    a. Intake port.
    b. Compensating port.
    c. Residual pressure valve.
    d. Pressure differential valve.

59. (208) Vacuum suspended boosters have
    a. atmospheric pressure on both sides of the diaphragm with the pedal released.
    b. atmospheric pressure on both sides of the diaphragm with the pedal applied.
    c. a vacuum on both sides of the diaphragm with the pedal released.
    d. a vacuum on both sides of the diaphragm with the pedal applied.

60. (208) Which type of vehicle is *most* likely to have a power brake hydraulic booster?
    a. Gasoline.
    b. Flex-fuel.
    c. Hybrid.
    d. Diesel.

61. (208) Brake fluid's ability to be free flowing at *all* temperatures refers to
    a. viscosity.
    b. water tolerance.
    c. high boiling point.
    d. low freezing point.

62. (208) In a disc brake system, what caliper component helps pull the piston back into the cylinder after the brakes are released?
    a. Metering valve.
    b. Return spring.
    c. Piston seal.
    d. Pin.

63. (208) How are disc brake pad linings mounted to the disc brake pads?
    a. Riveted or bonded.
    b. Riveted or welded.
    c. Bolted or screwed.
    d. Bolted or spring-held.

64. (208) Which caliper types are free to move in relation to the disc?
    a. Fixed and rigid.
    b. Sliding and rotating.
    c. Floating and sliding.
    d. Rigid and four-piston.

65. (208) In a disc brake system, a fixed caliper is attached directly to the steering knuckle with
    a. a locking shaft.
    b. a support key.
    c. guide pins.
    d. bolts.

66. (208) The brake shoes are held against the backing plate by
    a. hold-down springs.
    b. hold-down screws.
    c. return springs.
    d. return clips.

67. (208) Automatic brake shoe adjusters normally function when the brakes are applied with the vehicle
    a. moving forward.
    b. parking brake set.
    c. moving in reverse.
    d. completely stopped.

68. (208) With self-energizing action, when brake shoes are
    a. released and pull away from the rotating drum, they are pulled away from their pivot point by friction.
    b. released and pull away from the rotating drum, they are pressed into their pivot point by friction.
    c. forced against the rotating drum, they are pulled away from their pivot point by friction.
    d. forced against the rotating drum, they are pressed into their pivot point by friction.

69. (208) Servo action supplements drum brake shoe energization and results when
    a. the primary shoe helps apply the secondary shoe.
    b. the secondary shoe helps apply the primary shoe.
    c. both brake shoes try to rotate in the opposite direction from the brake drum.
    d. the star-wheel adjuster pushes the primary shoe against the drum with extra force.

70. (208) Which brake control valve warns the driver of pressure loss in either the primary or secondary brake system?
    a. Pressure differential valve.
    b. Proportioning valve.
    c. Combination valve.
    d. Metering valve.

71. (208) A combination valve functions as all of the following *except*
    a. metering valve.
    b. fluid level sensor.
    c. proportioning valve.
    d. warning light switch.

72. (208) An electric parking brake uses the brake system control module to mechanically engage the rear brakes by operating a
    a. pressure switch.
    b. lockout relay.
    c. servo motor.
    d. solenoid.

73. (209) Which condition is usually caused by air in the brake system?
    a. Spongy pedal.
    b. Pulling brakes.
    c. Dragging brakes.
    d. Brake warning light on.

74. (209) Which of the following is *not* an application specification checked during a brake pedal check?
    a. Height.
    b. Free play.
    c. Reserve distance.
    d. Application pressure.

75. (209) How far should the pedal or lever move when checking the parking brake?
    a. Through its full travel.
    b. At least 2/3 of its full travel.
    c. No more than 1/2 of its full travel.
    d. No more than 2/3 of its full travel.

76. (209) When a master cylinder fails and you find brake fluid in the rear boot or on the firewall, the diagnosis would show that it has
    a. fluid leaking past the rear piston.
    b. a power booster diaphragm leak.
    c. a clogged compensating port.
    d. a leaky compensating port.

77. (209) What should you use to clean master cylinder parts during a rebuild?
    a. Degreaser.
    b. Mild soap.
    c. Water only.
    d. Brake fluid.

78. (209) Which wheel brake assembly do you typically start with during a manual brake system bleeding?
    a. Whichever wheel you worked on first.
    b. Whichever wheel you worked on last.
    c. Farthest from the master cylinder.
    d. Closest to the master cylinder.

79. (209) When using a pressure bleeder, charge it in pounds per square inch (psi) to an air pressure of
    a. 10 to 15 psi.
    b. 25 to 35 psi.
    c. at least 50 psi.
    d. at least 100 psi.

80. (209) When replacing disc brake pads, you can retract the caliper pistons by using a caliper tool or
    a. hydraulic press.
    b. C-clamp.
    c. hammer.
    d. pry bar.

81. (209) What device is used to check a brake disc's runout?
    a. Micrometer.
    b. Straight edge.
    c. Dial indicator.
    d. Strip-type feeler gauge.

82. (209) Brake disc resurfacing may correct each of the following *except*
    a. thickness variation.
    b. cracking.
    c. scoring.
    d. runout.

83. (209) If a drum is rusted to the axle flange, what action should you take to remove it?
    a. Lightly tap the outside edge of the drum with a hammer.
    b. Lightly tap the inside lip of the drum with a hammer.
    c. Use a special brake drum puller kit.
    d. Apply penetrating oil overnight.

84. (209) Typically, a brake should not be oversize more than
    a. .006".
    b. .050".
    c. .060".
    d. .500".

85. (209) To keep the shoes from squeaking after a brake job you should
    a. clean the hold-down pins.
    b. replace the return springs.
    c. lubricate the small pads on the backing plate.
    d. lubricate the threads and slot end of the star adjuster.

86. (209) During a parking brake adjustment, how far should the parking brake lever or pedal be engaged?
    a. One notch.
    b. Engaged fully.
    c. Released completely.
    d. Approximately half way.

87. (210) For maximum stopping power with anti-lock brakes, you want the tires to
    a. almost, but not quite, skid.
    b. skid until the vehicle stops.
    c. lock up until the vehicle stops.
    d. turn alternately left and right until the vehicle stops.

88. (210) How does a wheel speed sensor generate and send voltage signal to the computer?
    a. Magnetic sensor tip, sensor rotor teeth, and resulting magnetic field.
    b. Magnetic sensor pickup and magnetic fusion.
    c. Light emitting diode.
    d. Inferred signal.

89. (210) What is the purpose of a brake accumulator in an anti-lock brake electro-hydraulic modulator?
    a. Store extra fluid under high pressure.
    b. Store extra fluid under low pressure.
    c. Increase pressure at the fluid sump.
    d. Reduce primary circuit pressure.

90. (210) What anti-lock brake system has a conventional booster and master cylinder, which are separate from the electro-hydraulic modulator?
    a. Single channel.
    b. Nonintegrated.
    c. Multichannel.
    d. Integrated.

91. (210) Each of the following is a mode of anti-lock brake system pressure modulation *except*
    a. dump mode.
    b. reapply mode.
    c. isolation mode.
    d. emergency mode.

92. (210) In a one-channel anti-lock brake system, the single channel normally operates
    a. the front wheel brakes together.
    b. the rear wheel brakes together.
    c. four wheels at once.
    d. one wheel at a time.

93. (210) How many channels are there in an anti-lock brake system that controls each wheel individually during an anti-lock stop?
    a. 1.
    b. 2.
    c. 3.
    d. 4.

94. (210) If *understeer* is detected, which wheel does the stability control module apply force to?
    a. Inside rear.
    b. Inside front.
    c. Outside rear.
    d. Outside front.

95. (210) How do many manufacturers recommend you relieve the high hydraulic pressure stored in an anti-lock brake system to render it safe to service?
    a. Hold a leather glove or apron over a fitting while you loosen it.
    b. Manually actuate the pressure dump valve.
    c. Pump the brake pedal at least 40 times.
    d. Let the vehicle sit overnight.

96. (210) Which of the following cannot be checked while using a scan tool to troubleshoot a brake system?
    a. Wheel speed sensor circuits.
    b. Brake lining condition.
    c. Trouble code history.
    d. Brake switch circuit.

97. (211) If a trailer has an electric brake system, the emergency breakaway regulation requires that the trailer be equipped with
    a. an extendable toe hitch system.
    b. an emergency battery backup system.
    c. a 5-pin connector that uses the center pin for a ground circuit.
    d. a hydraulic reservoir for additional emergency braking support.

98. (211) What is required as an additional component for a hydraulic drum (surge) brake system on a trailer to reduce hydraulic pressure and deactivate the brakes when backing up?
    a. Hydraulic surge brake coupler.
    b. Hand-operated control valve.
    c. Hydraulic purge valve.
    d. Reverse solenoid.

99. (211) As power is applied to the electromagnets in the brake cluster of electric brakes, what component applies the brake shoes to the drum?
    a. The lever arm of the brake-actuating cam.
    b. Magnets pull directly on the brake shoes directly.
    c. A wheel cylinder is expanded by a lever arm in the hub.
    d. A brake control solenoid extends, pushing the brake shoes out.

100. (211) What component is used on a dash-mounted inertial deceleration controller to activate the electric braking system?
    a. Manual adjusted rheostat switch.
    b. Inertial mass attached to a pendulum.
    c. Electrical plug connector that attaches to the brake light switch circuit.
    d. A digital capacitor that detects vehicle inertia and adjusts magnetic current flow.

Student Notes

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