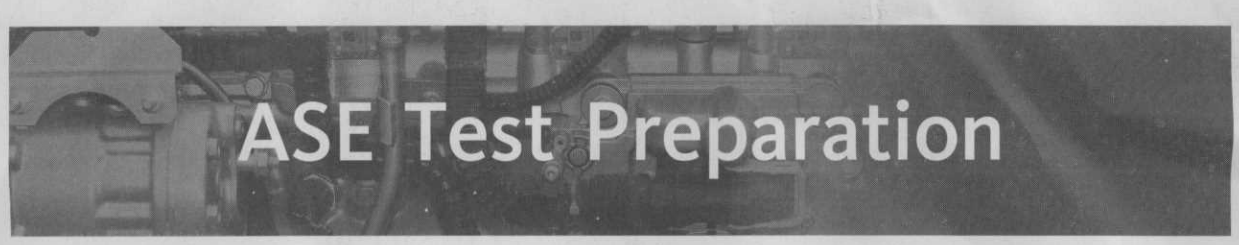
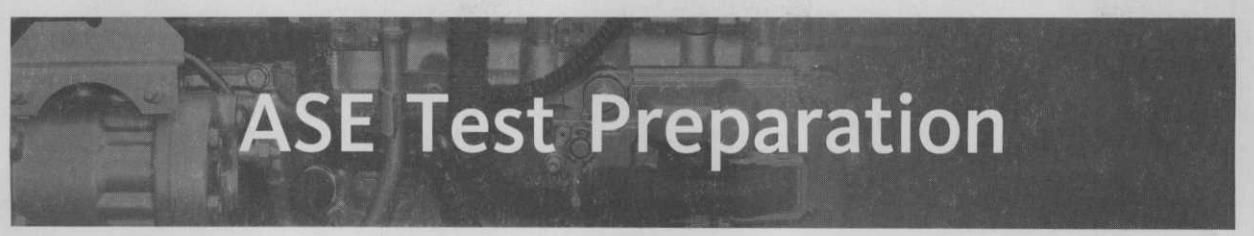


Automotive Technician Certification Series

Auto Maintenance and Light Repair (G1)



Automotive Technician Certification Series

Auto Maintenance and Light Repair (G1)

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ASE Test Preparation: Automotive Technician Series, Auto Maintenance and Light Repair (G1)

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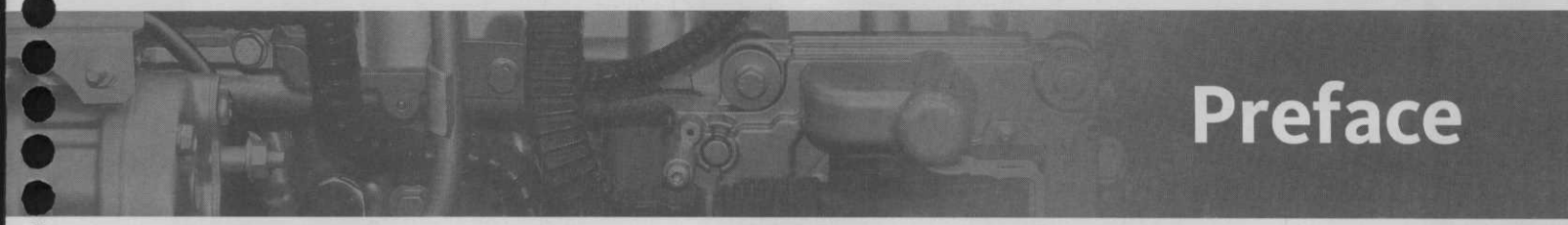
Table of Contents



Preface

Delmar, a part of Cengage Learning, is very pleased that you have chosen to use our ASE Test Preparation Guide to help prepare yourself for the Auto Maintenance and Light Repair (G1) ASE certification examination. This guide is designed to help prepare you for your actual exam by providing you with an overview and introduction of the testing process, introducing you to the task list for the Auto Maintenance and Light Repair (G1) certification exam, giving you an understanding of what knowledge and skills you are expected to have in order to successfully perform the duties associated with each task area, and providing you with several preparation exams designed to emulate the live exam content in hopes of assessing your overall exam readiness.

If you have a basic working knowledge of the discipline you are testing for, you will find this book is an excellent guide, helping you understand the "must know" items needed to successfully pass the ASE certification exam. This manual is not a textbook. Its objective is to prepare the individual who has the existing requisite experience and knowledge to attempt the challenge of the ASE certification process. This guide cannot replace the hands-on experience and theoretical knowledge required by ASE to master the vehicle repair technology associated with this exam. If you are unable to understand more than a few of the preparation questions and their corresponding explanations in this book, it could be that you require either more shop-floor experience or further study.

This book begins by providing an overview of, and introduction to, the testing process. This section outlines what we recommend you do to prepare, what to expect on the actual test day, and overall methodologies for your success. This section is followed by a detailed overview of the ASE task list to include explanations of the knowledge and skills you must possess to successfully answer questions related to each particular task. After the task list, we provide six sample preparation exams for you to use as a means of evaluating areas of understanding, as well as areas requiring improvement in order to successfully pass the ASE exam. Delmar is the first and only test preparation organization to provide so many unique preparation exams. We enhanced our guides to include this support as a means of providing you with the best preparation product available. Section 6 of this guide includes the answer keys for each preparation exam, along with the answer explanations for each question. Each answer explanation also contains a reference back to the related task or tasks that it assesses. This will provide you with a quick and easy method for referring back to the task list whenever needed. The last section of this book contains blank answer sheet forms you can use as you attempt each preparation exam, along with a glossary of terms.

OUR COMMITMENT TO EXCELLENCE

Thank you for choosing Delmar, Cengage Learning for your ASE test preparation needs. All of the writers, editors, and Delmar staff have worked very hard to make this test preparation guide second to none. We feel confident that you will find this guide easy to use and extremely beneficial as you prepare for your actual ASE exam.

Delmar, Cengage Learning has sought out the best subject-matter experts in the country to help with the development of ASE Test Preparation: Automotive Technician Certification Series, Auto Maintenance and Light Repair, 1st Edition.

Preparation questions are authored and then reviewed by a group of certified, subject-matter experts to ensure the highest level of quality and validity to our product.

If you have any questions concerning this guide or any guide in this series, please visit us on the web at http://www.trainingbay.cengage.com.

For web-based online test preparation for ASE certifications, please visit us on the web at http://www.techniciantestprep.com/ to learn more.

ABOUT THE AUTHOR

Bob Rodriguez is a long-time instructor of automotive electrical, gasoline and diesel injection systems and specializes in alternative fuels and alternative fuel vehicles. Bob's background includes training design and development, training management, delivery, and assessment. Bob is certified by ASE as a Master Automobile Technician (CMAT), and Advanced Level Specialist (L1), a Light Diesel Vehicle Specialist, and Alternate Fuels Technician, and a Parts Specialist (P2). He has been certified as a CNG Cylinder Inspector through CSA, and is trained in advanced automobile electronics and OBD-II systems service.

ABOUT THE SERIES ADVISOR

Randy Nussler became an automotive technician in 1988 and a full time automotive instructor at Midlands Technical College in Columbia, South Carolina in 2005. He earned an Associate in Science Degree in Automotive Technology from New England Institute of Technology. He holds the industry certifications of ASE Master Certified with L1, X1, Undercar Specialist Certified and Subaru Factory Certified Technician.

Randy is active in professional associations as North American Council of Automotive Teachers-South Carolina Chapter (NACAT SC) elected-president and is a member of NACAT, NISOD and IATN. He frequently attends industry training, conferences and serves on a local high schools automotive advisory committee. He is grateful to have been the 2011 Delmar Cengage Jack Erjavec Innovative Instructor Scholarship Award recipient.

SECTION 1

The History and Purpose of ASE

ASE began as the National Institute for Automotive Service Excellence (NIASE). It was founded as a non-profit, independent entity in 1972 by a group of industry leaders with the single goal of providing a means for consumers to distinguish between incompetent and competent technicians. It accomplishes this goal through the testing and certification of repair and service professionals. Though it is still known as the National Institute for Automotive Service Excellence, it is now called "ASE" for short.

Today, ASE offers more than 40 certification exams in automotive, medium/heavy duty truck, collision repair and refinish, school bus, transit bus, parts specialist, automobile service consultant, and other industry-related areas. At this time, there are more than 385,000 professionals nationwide with current ASE certifications. These professionals are employed by new car and truck dealerships, independent repair facilities, fleets, service stations, franchised service facilities, and more.

ASE's certification exams are industry-driven and cover practically every on-highway vehicle service segment. The exams are designed to stress the knowledge of job-related skills. Certification consists of passing at least one exam and documenting two years of relevant work experience. To maintain certification, those with ASE credentials must be re-tested every five years.

While ASE certifications are a targeted means of acknowledging the skills and abilities of an individual technician, ASE also has a program designed to provide recognition for highly qualified repair, support, and parts businesses. The Blue Seal of Excellence Recognition Program, allows businesses to showcase their technicians and their commitment to excellence. One of the requirements of becoming Blue Seal recognized is that the facility must have a minimum of 75 percent of their technicians ASE certified. Additional criteria apply, and program details can be found on the ASE website.

ASE recognized that educational programs serving the service and repair industry also needed a way to be recognized as having the faculty, facilities, and equipment to provide a quality education to students wanting to become service professionals. Through the combined efforts of ASE, industry, and education leaders, the non-profit organization entitled the National Automotive Technicians Education Foundation (NATEF) was created in 1983 to evaluate and recognize academic programs. Today more than 2,000 educational programs are NATEF certified.

For additional information about ASE, NATEF, or any of their programs, the following contact information can be used:

National Institute for Automotive Service Excellence (ASE)
101 Blue Seal Drive S.E.
Suite 101
Leesburg, VA 20175
Telephone: 703-669-6600
Fax: 703-669-6123
Website: **www.ase.com**

SECTION

2 Overview and Introduction

Participating in the National Institute for Automotive Service Excellence (ASE) voluntary certification program provides you with the opportunity to demonstrate you are a qualified and skilled professional technician who has the "know-how" required to successfully work on today's modern vehicles.

EXAM ADMINISTRATION

> *Note:* After November 2011, ASE will no longer offer paper and pencil certification exams. There will be no Winter testing window in 2012, and ASE will offer and support CBT testing exclusively starting in April 2012.

ASE provides computer-based testing (CBT) exams, which are administered at test centers across the nation. It is recommended that you go to the ASE website at http://www.ase.com and review the conditions and requirements for this type of exam. There is also an exam demonstration page that allows you to personally experience how this type of exam operates before you register.

CBT exams are available four times annually, for two-month windows, with a month of no testing in between each testing window:

- January/February—Winter testing window
- April/May—Spring testing window
- July/August—Summer testing window
- October/November—Fall testing window

Please note, testing windows and timing may change. It is recommended you go to the ASE website at ***http://www.ase.com*** and review the latest testing schedules.

UNDERSTANDING TEST QUESTION BASICS

ASE exam questions are written by service industry experts. Each question on an exam is created during an ASE-hosted "item-writing" workshop. During these workshops, expert service representatives from manufacturers (domestic and import), aftermarket parts and equipment manufacturers, working technicians, and technical educators gather to share ideas and convert them into actual exam questions. Each exam question written by these experts must then survive review by all members of the group. The questions are designed to address the practical application of repair and diagnosis knowledge and skills practiced by technicians in their day-to-day work.

After the item-writing workshop, all questions are pre-tested and quality-checked on a national sample of technicians. Those questions that meet ASE standards of quality and accuracy are

included in the scored sections of the exams; the "rejects" are sent back to the drawing board or discarded altogether.

Depending on the topic of the certification exam, you will be asked between 40 and 80 multiple-choice questions. You can determine the approximate number of questions you can expect to be asked during the Auto Maintenance and Light Repair (G1) certification exam by reviewing the task list in Section 4 of this book. The five-year recertification exam will cover this same content; however, the number of questions for each content area of the recertification exam will be reduced by approximately one-half.

> *Note:* Exams may contain questions that are included for statistical research purposes only. Your answers to these questions will not affect your score, but since you do not know which ones they are, you should answer all questions in the exam.

Using multiple criteria, including cross-sections by age, race, and other background information, ASE is able to guarantee that exam questions do not include bias for or against any particular group. A question that shows bias toward any particular group is discarded.

TEST-TAKING STRATEGIES

Before beginning your exam, quickly look over the exam to determine the total number of questions that you will need to answer. Having this knowledge will help you manage your time throughout the exam to ensure you have enough available to answer all of the questions presented. Read through each question completely before marking your answer. Answer the questions in the order they appear on the exam. Leave the questions blank that you are not sure of and move on to the next question. You can return to those unanswered questions after you have finished the others. These questions may actually be easier to answer at a later time once your mind has had additional time to consider them on a subconscious level. In addition, you might find information in other questions that will help you recall the answers to some of them.

Multiple-choice exams are sometimes challenging because there are often several choices that may seem possible, or partially correct, and therefore it may be difficult to decide on the most appropriate answer choice. The best strategy, in this case, is to first determine the correct answer before looking at the answer options. If you see the answer you decided on, you should still be careful to examine the other answer options to make sure that none seem more correct than yours. If you do not know or are not sure of the answer, read each option very carefully and try to eliminate those options that you know are incorrect. That way, you can often arrive at the correct choice through a process of elimination.

If you have gone through the entire exam, and you still do not know the answer to some of the questions, *then guess.* Yes, guess. You then have at least a 25 percent chance of being correct. While your score is based on the number of questions answered correctly, any question left blank, or unanswered, is automatically scored as incorrect.

There is a lot of "folk" wisdom on the subject of test taking that you may hear about as you prepare for your ASE exam. For example, there are those who would advise you to avoid response options that use certain words such as *all, none, always, never, must,* and *only,* to name a few. This, they claim, is because nothing in life is exclusive. They would advise you to choose response options that use words that allow for some exception, such as *sometimes, frequently, rarely, often, usually, seldom,* and *normally.* They would also advise you to avoid the first and last option (A or D) because exam writers, they feel, are more comfortable if they put the correct answer in the middle (B or C) of the choices. Another recommendation often offered is to select the option that is either shorter or longer than the other three choices because it is more likely to be correct. Some would advise you to never change an answer since your first intuition is usually correct. Another area of "folk" wisdom focuses specifically on any repetitive patterns created by your question responses (e.g., A, B, C, A, B, C, A, B, C).

Many individuals may say that there are actual grains of truth in this "folk" wisdom, and whereas with some exams, this may prove true, it is not relevant in regard to the ASE certification exams. ASE validates all exam questions and test forms through a national sample of technicians, and only those questions and test forms that meet ASE standards of quality and accuracy are included in the scored sections of the exams. Any biased questions or patterns are discarded altogether, and therefore, it is highly unlikely you will experience any of this "folk" wisdom on an actual ASE exam.

PREPARING FOR THE EXAM

Delmar, Cengage Learning wants to make sure we are providing you with the most thorough preparation guide possible. To demonstrate this, we have included hundreds of preparation questions in this guide. These questions are designed to provide as many opportunities as possible to prepare you to successfully pass your ASE exam. The preparation approach we recommend and outline in this book is designed to help you build confidence in demonstrating what task area content you already know well while also outlining what areas you should review in more detail prior to the actual exam.

We recommend that your first step in the preparation process should be to thoroughly review Section 3 of this book. This section contains a description and explanation of the type of questions you'll find on an ASE exam.

Once you understand how the questions will be presented, we then recommend that you thoroughly review Section 4 of this book. This section contains information that will help you establish an understanding of what the exam will be evaluating, and specifically, how many questions to expect in each specific task area.

As your third preparatory step, we recommend you complete your first preparation exam, located in Section 5 of this book. Answer one question at a time. After you answer each question, review the answer and question explanation information located in Section 6. This section will provide you with instant response feedback, allowing you to gauge your progress, one question at a time, throughout this first preparation exam. If after reading the question explanation you do not feel you understand the reasoning for the correct answer, go back and review the task list overview (Section 4) for the task that is related to that question. Included with each question explanation is a clear identifier of the task area that is being assessed (e.g., Task A.1). If at that point you still do not feel you have a solid understanding of the material, identify a good source of information on the topic, such as an educational course, textbook, or other related source of topical learning, and do some additional studying.

After you have completed your first preparation exam and have reviewed your answers, you are ready to complete your next preparation exam. A total of six practice exams are available in Section 5 of this book. For your second preparation exam, we recommend that you answer the questions as if you were taking the actual exam. Do not use any reference material or allow any interruptions in order to get a feel for how you will do on the actual exam. Once you have answered all of the questions, grade your results using the Answer Key in Section 6. For every question that you gave an incorrect answer to, study the explanations to the answers and/or the overview of the related task areas. Try to determine the root cause for missing the question. The easiest thing to correct is learning the correct technical content. The hardest things to correct are behaviors that lead you to an incorrect conclusion. If you knew the information but still got the question incorrect, there is likely a test-taking behavior that will need to be corrected. An example of this would be reading too quickly and skipping over words that affect your reasoning. If you can identify what you did that caused you to answer the question incorrectly, you can eliminate that cause and improve your score.

Here are some basic guidelines to follow while preparing for the exam:

- Focus your studies on those areas you are weak in.
- Be honest with yourself when determining if you understand something.
- Study often but for short periods of time.
- Remove yourself from all distractions when studying.
- Keep in mind that the goal of studying is not just to pass the exam; the real goal is to learn.
- Prepare physically by getting a good night's rest before the exam, and eat meals that provide energy but do not cause discomfort.
- Arrive early to the exam site to avoid long waits as test candidates check in.
- Use all of the time available for your exams. If you finish early, spend the remaining time reviewing your answers.
- Do not leave any questions unanswered. If absolutely necessary, guess. All unanswered questions are automatically scored as incorrect.

Here are some items you will need to bring with you to the exam site:

- A valid government or school-issued photo ID
- Your test center admissions ticket
- A watch (not all test sites have clocks)

> *Note:* Books, calculators, and other reference materials are not allowed in the exam room. The exceptions to this list are English-Foreign dictionaries or glossaries. All items will be inspected before and after testing.

WHAT TO EXPECT DURING THE EXAM

When taking a CBT exam, as soon as you are seated in the testing center, you will be given a brief tutorial to acquaint you with the computer-delivered test prior to taking your certification exam(s). The CBT exams allow you to select only one answer per question. You can also change your answers as many times as you like. When you select a second answer choice, the CBT will automatically unselect your first answer choice. If you want to skip a question to return to later, you can utilize the "flag" feature, which will allow you to quickly identify and review questions whenever you are ready. Prior to completing your exam, you will also be provided with an opportunity to review your answers and address any unanswered questions.

TESTING TIME

Each individual ASE CBT exam has a fixed time limit. Individual exam time will vary based upon exam area, and will range anywhere from a half hour to two hours. You will also be given an additional 30 minutes beyond what is allotted to complete your exams to ensure you have adequate time to perform all necessary check-in procedures, complete a brief CBT tutorial, and potentially complete a post-test survey.

You can register for and take multiple CBT exams during one testing appointment. The maximum time allotment for a CBT appointment is four and a half hours. If you happen to register for so many exams that you will require more time than this, your exams will be scheduled into multiple

appointments. This could mean that you have testing on both the morning and afternoon of the same day, or they could be scheduled on different days, depending on your personal preference and the test center's schedule.

It is important to understand that if you arrive late for your CBT test appointment, you will not be able to make up any missed time. You will only have the scheduled amount of time remaining in your appointment to complete your exam(s).

Also, while most people finish their CBT exams within the time allowed, others might feel rushed or not be able to finish the test, due to the implied stress of a specific, individual time limit allotment. Before you register for the CBT exams, you should review the number of exam questions that will be asked along with the amount of time allotted for that exam to determine whether you feel comfortable with the designated time limitation or not.

As an overall time management recommendation, you should monitor your progress and set a time limit you will follow with regard to how much time you will spend on each individual exam question. This should be based on the total number of questions you will be answering.

Also, it is very important to note that if for any reason you wish to leave the testing room during an exam, you must first ask permission. If you happen to finish your exam(s) early and wish to leave the testing site before your designated session appointment is completed, you are permitted to do so only during specified dismissal periods.

UNDERSTANDING HOW YOUR EXAM IS SCORED

You can gain a better perspective about the ASE certification exams if you understand how they are scored. ASE exams are scored by an independent organization having no vested interest in ASE or in the automotive industry. With CBT exams, you will receive your exam scores immediately.

Each question carries the same weight as any other question. For example, if there are 50 questions, each is worth 2 percent of the total score.

Your exam results can tell you:

- Where your knowledge equals or exceeds that needed for competent performance, or
- Where you might need more preparation.

Your ASE exam score report is divided into content "task" areas; it will show the number of questions in each content area and how many of your answers were correct. These numbers provide information about your performance in each area of the exam. However, because there may be a different number of questions in each content area of the exam, a high percentage of correct answers in an area with few questions may not offset a low percentage in an area with many questions.

It should be noted that one does not "fail" an ASE exam. The technician who does not pass is simply told "More Preparation Needed." Though large differences in percentages may indicate problem areas, it is important to consider how many questions were asked in each area. Since each exam evaluates all phases of the work involved in a service specialty, you should be prepared in each area. A low score in one area could keep you from passing an entire exam. If you do not pass the exam, you may take it again at any time it is scheduled to be administered.

There is no such thing as average. You cannot determine your overall exam score by adding the percentages given for each task area and dividing by the number of areas. It doesn't work that way because there generally are not the same number of questions in each task area. A task area with 20 questions, for example, counts more toward your total score than a task area with 10 questions.

Your exam report should give you a good picture of your results and a better understanding of your strengths and areas needing improvement for each task area.

SECTION 3

Types of Questions on an ASE Exam

Understanding not only what content areas will be assessed during your exam, but how you can expect exam questions to be presented will enable you to gain the confidence you need to successfully pass an ASE certification exam. The following examples will help you recognize the types of question styles used in ASE exams and assist you in avoiding common errors when answering them.

Most initial certification tests are made up of between 40 and 80 multiple-choice questions. The five-year recertification exams will cover the same content as the initial exam; however, the actual number of questions for each content area will be reduced by approximately one-half. Refer to Section 4 of this book for specific details regarding the number of questions to expect during the initial Engine Repair (A1) certification exam.

Multiple-choice questions are an efficient way to test knowledge. To correctly answer them, you must consider each answer choice as a possibility, and then choose the answer choice that *best* addresses the question. To do this, read each word of the question carefully. Do not assume you know what the question is asking until you have finished reading the entire question.

About 10 percent of the questions on an actual ASE exam will reference an illustration. These drawings contain the information needed to correctly answer the question. The illustration should be studied carefully before attempting to answer the question. When the illustration is showing a system in detail, look over the system and try to figure out how the system works before you look at the question and the possible answers. This approach will ensure that you do not answer the question based upon false assumptions or partial data, but instead have reviewed the entire scenario being presented.

MULTIPLE-CHOICE/DIRECT QUESTIONS

The most common type of question used on an ASE exam is the direct multiple-choice style question. This type of question contains an introductory statement, called a stem, followed by four options: three incorrect answers, called distracters, and one correct answer, the key.

When the questions are written, the point is to make the distracters plausible to draw an inexperienced technician to inadvertently select one of them. This type of question gives a clear indication of the technician's knowledge.

Here is an example of a direct style question:

1. Which of the following would be used to check for rotor runout on a disc brake system?

   A. Dial indicator
   B. Vernier caliper
   C. Outside micrometer
   D. Inside micrometer

TASK E.22

Answer A is correct. A dial indicator is used to measure rotor runout.

Answer B is incorrect. A Vernier caliper is not the correct instrument to use for measuring runout of a rotor.

Answer C is incorrect. An outside micrometer may be used to measure rotor thickness, but not runout.

Answer D is incorrect. An inside mic is not used to determine rotor runout.

COMPLETION QUESTIONS

A completion question is similar to the direct question except the statement may be completed by any one of the four options to form a complete sentence.

Here is an example of a completion question:


TASK A.14

2. Throttle body cleaning should be done by using:
   A. soap and water.
   B. silicone spray
   C. WD-40®
   D. OEM approved cleaner.

Answer A is incorrect. Soap and water will not be effective for removing carbon and could harm the sensitive MAF sensor if so equipped.

Answer B is incorrect. Silicone spray is a lubricant, not a cleaner.

Answer C is incorrect. WD-40 is also a lubricant, not a cleaner.

Answer D is correct. Only OEM approved cleansers should be used to clean a throttle body.

TECHNICIAN A, TECHNICIAN B QUESTIONS

This type of question is usually associated with an ASE exam. It is, in fact, two true-false statements grouped together, such as: "Technician A says..." and "Technician B says...", followed by "Who is correct?"

In this type of question, you must determine whether either, both, or neither of the statements are correct. To answer this type of question correctly, you must carefully read each technician's statement and judge it on its own merit.

Sometimes this type of question begins with a statement about some analysis or repair procedure. This statement provides the setup or background information required to understand the conditions about which Technician A and Technician B are talking, followed by two statements about the cause of the concern, proper inspection, identification, or repair choices.

Analyzing this type of question is a little easier than the other types because there are only two ideas to consider, although there are still four choices for an answer.

Again, Technician A, Technician B questions are really double true-or-false questions. The best way to analyze this type of question is to consider each technician's statement separately. Ask yourself, "Is A true or false? Is B true or false?" Once you have completed this individual evaluation of each answer choice, you will have successfully determined the correct answer choice for the question, "Who is correct?"

An important point to remember is that an ASE Technician A, Technician B question will never have Technician A and B directly disagreeing with each other. That is why you must evaluate each statement independently.

An example of a Technician A/Technician B style question looks like this:

1. A water pump is being replaced on an engine. Technician A says that on some engines a serpentine belt must first be removed. Technician B says that on some engines the timing belt must first be removed. Who is correct?

   A. A only
   B. B only
   C. Both A and B
   D. Neither A nor B


TASK A.11

Answer A is incorrect. Technician B is also correct.

Answer B is incorrect. Technician A is also correct.

Answer C is correct. Both Technicians are correct. Some engines have a serpentine belt driven water pump. On other engines the water pump may be driven by a timing belt.

Answer D is incorrect. Both Technicians A and B are making correct statements.

EXCEPT QUESTIONS

Another type of question type used on the ASE exams contains answer choices that are all correct except for one. To help easily identify this type of question, whenever it is presented in an exam, the word "EXCEPT" will always be displayed in capital letters. Furthermore, a cautionary statement will alert you to the fact that the next question is different from the ones otherwise found in the exam. With the EXCEPT type of question, only one ***incorrect*** choice will actually be listed among the options, and that incorrect choice will be the key to the question. That is, the incorrect statement is counted as the correct answer for that question.

Be careful to read these question types slowly and thoroughly; otherwise, you may overlook what the question is actually asking and answer the question by selecting the first correct statement.

An example of this type of question would appear as follows:

1. A diesel engine is being checked for an engine oil leak. Any of these could be used to help locate the source of the leak EXCEPT:

   A. Black light.
   B. White powder.
   C. Vacuum gauge.
   D. Oil dye.


TASK A.2

Answer A is incorrect. A black light can be used to help locate the source of a leak.

Answer B is incorrect. White powder can be used to help locate the source of a leak.

Answer C is correct. A vacuum gauge is not used to locate engine oil leaks.

Answer D is incorrect. Oil dye may be used to help locate an engine oil leak.

LEAST LIKELY QUESTIONS

LEAST LIKELY questions are similar to EXCEPT questions. Look for the answer choice that would be the LEAST LIKELY cause (most incorrect) of the described situation. To help easily identify these types of question, whenever they are presented in an exam the words "LEAST LIKELY" will always be displayed in capital letters. In addition, you will be alerted before a LEAST LIKELY question is posed. Read the entire question carefully before choosing your answer.

An example of this type of question is shown here:

1. A vehicle equipped with a diesel engine overheats when pulling a trailer. Which of these would be the LEAST LIKELY cause?

   A. Slipping fan clutch
   B. Seized fan clutch
   C. Restricted charge air cooler
   D. Restricted radiator

A. 7
TASK A.12

Answer A is incorrect. A slipping fan clutch may not fully engage and would fail to provide sufficient air flow across the radiator to keep the engine cool.

Answer B is correct. A seized fan clutch would run all the time; this may cause a low power complaint, but **would not** cause the engine to overheat.

Answer C is incorrect. A restricted charge air cooler would also restrict the air flow across the radiator. This could result in an engine overheating condition.

Answer D is incorrect. A restricted radiator could result in an overheated engine.

SUMMARY

The question styles outlined in this section are the only ones you will encounter on any ASE certification exam. ASE does not use any other types of question styles, such as fill-in-the-blank, true/false, word-matching, or essay. ASE also will not require you to draw diagrams or sketches to support any of your answer selections, although any of the described question styles may include illustrations, charts, or schematics to clarify a question. If a formula or chart is required to answer a question, it will be provided for you.

SECTION 4

Task List Overview

INTRODUCTION

This section of the book outlines the content areas or *task list* for this specific certification exam, along with a written overview of the content covered in the exam.

The task list describes the actual knowledge and skills necessary for a technician to successfully perform the work associated with each skill area. This task list is the fundamental guideline you should use to understand what areas you can expect to be tested on, as well as how each individual area is weighted to include the approximate number of questions you can expect to be given for that area during the ASE certification exam. It is important to note that the number of exam questions for a particular area is to be used as a guideline only. ASE advises that the questions on the exam may not equal the number specifically listed on the task list. The task lists are specifically designed to tell you what ASE expects you to know how to do and to help prepare you to be tested.

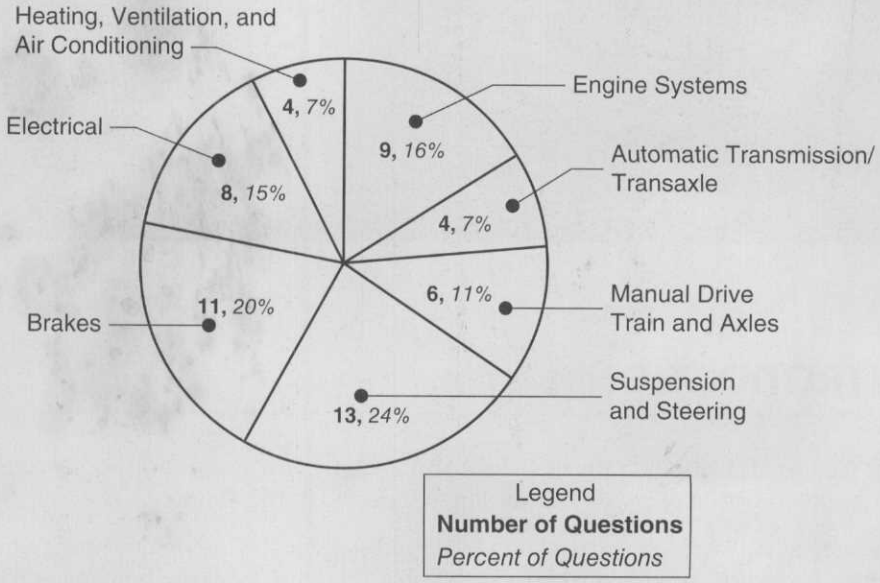
Similar to the role this task list will play in regard to the actual ASE exam, Delmar, Cengage Learning has developed six preparation exams, located in Section 5 of this book, using this task list as a guide. It is important to note that although both ASE and Delmar, Cengage Learning use the same task list as a guideline for creating these test questions, none of the test questions you will see in this book will be found in the actual, live ASE exams. This is true for any test preparatory material you use. Real exam questions are *only* visible during the actual ASE exams.

Task List at a Glance

The Auto Maintenance and Light Repair (G1) task list focuses on 7 core areas, and you can expect to be asked a total of approximately 55 questions on your certification exam, broken out as outlined:

A. Engine Systems (9 Questions)
B. Automatic Transmission/Transaxle (4 Questions)
C. Manual Drive Train and Axles (6 Questions)
D. Suspension and Steering (13 Questions)
E. Brakes (11 Questions)
F. Electrical (8 Questions)
G. Heating, Ventilation, and Air Conditioning (4 Questions)

Based upon this information, below is a general graphical guideline demonstrating which areas will have the most focus on the actual certification exam. This data may help you prioritize your time when preparing for the exam.



Note: The actual number of questions you will be given on the ASE certification exam may vary slightly from the information provided in the task list, as exams may contain questions that are included for statistical research purposes only. Do not forget that your answers to these research questions will not affect your score.

TASK LIST AND OVERVIEW

A. Engine Systems (9 questions)

1. Verify driver's complaint and/or road test vehicle; determine necessary action. Utilize service manuals, technical service bulletins (TSBs), and product information.

Before starting to work on any vehicle, it is important to gather as much information as you can in order to avoid wasting time and effort. You will need to read the customer's concern written on the repair order carefully to determine just what needs to be addressed. Perhaps the vehicle is simply in for scheduled maintenance, or perhaps for an unscheduled diagnosis and repair. Sometimes interviewing the customer and going for a test drive are the best ways to investigate the driver's concerns. Perhaps simply understanding and following the instructions in the vehicle owner's manual will solve the problem.

Once the vehicle owner's complaint is verified, consult the latest Technical Service Bulletins (TSBs) for the latest service manual updates and/or information related to the customer's specific complaint. Often consulting on-line forums or services such as iATN® or Identifix® will lead you to an experience-based solution to the customer's vehicle problem.

Finally, consider consulting the TSBs, catalogs, and manuals provided by parts suppliers for additional service tips related to their specific products.

2. Inspect engine assembly for fuel, oil, coolant, and other leaks; determine necessary action.

A routine engine inspection should include looking both underhood and undercar for gasoline or diesel fuel, oil, coolant, or other forms of leakage. Most fluids have distinct odors and colors that help to identify what they are.

Valve covers and front or rear crankshaft seals are notorious places from which high mileage engines may leak oil. Coolant may seep from a leaking head gasket, thermostat housing, or freeze plug. In severe cases, a cracked head or engine block may exhibit a coolant or oil leak. In cases other than leaking gaskets, a major repair requiring head removal or removing the crankshaft may be needed to fix the leakage problem.

3. Check for abnormal engine noises.

Internal gasoline engines make all sorts of noises during normal operation, ranging from combustion noise, to exhaust noise to light or heavy mechanical sounds. These include squealing, rattling, ticking, clunking and anywhere in between. Normal noises may include light tappet noise or the sound of belts running in their pulleys.

When the starter is engaged, the engine should crank at a reasonably sufficient rpm (see manufacturer's specifications). Most manufacturers of electronically controlled gasoline or diesel fuel-injected engines will not inject fuel until about 150 rpm. The cranking speed can be easily verified with an electronic scan tool connected to the engine.

During a test drive, listen for abnormal combustion sounds like pinging or detonation which can be caused by any number of faults, from bad/contaminated gasoline to a faulty EGR valve system, or an intake leak which may be heard as a "whistling" sound.

Engine noises may originate from many areas. Engine crankshaft bearing noises are usually located lower in the engine and are referred to as a knock, occurring at crankshaft speed. The sources of these noises can be determined by raising engine rpm and noting any change in noise intensity. They are also diagnosed by removing combustion from the cylinder. In earlier engines this was done by pulling a spark plug wire from the spark plug, or loosening a high-pressure diesel injection line. In electronically controlled engines this is done by using the electronic scan tool in an Interactive Diagnosis mode. If the noise goes away when the spark or fuel delivery is removed, then the noise is usually considered to be a rod bearing problem. A double knock that does not go away when the fuel is removed from the combustion chamber is usually a piston pin (wrist pin).

Noises that come from the valve train are generally located higher in the engine and occur at ½ crankshaft speed. These noises are usually lighter in sound and generally referred to as a ticking or clicking. Causes of valve train noises may include worn cam lobes, lifters (followers), rocker arms, and bent push rods. Loud ticking noises or rattling could also mean low oil pressure being supplied to the valve train, or collapsed lifters due to incorrect motor oil or lack of maintenance. Squeals may mean a dry or worn serpentine or "V" belt. Listen for a noisy belt tensioner or pulleys requiring replacement.

All of these kinds of noises may best be located and isolated by using a stethoscope, or simply by probing with a piece of rubber tubing placed to one's ear. Use caution when doing so to avoid tangling with moving engine parts.

4. Inspect and replace pans and covers.

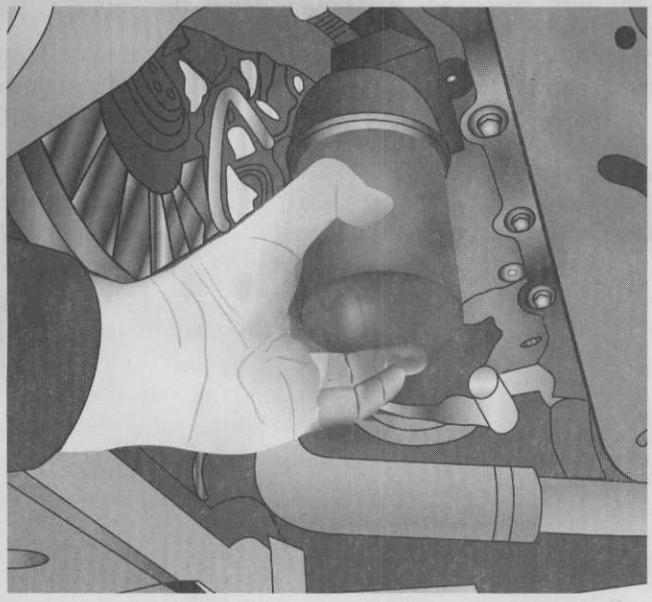
Check the oil pan and valve cover gaskets for leaks. Sometimes loosening and retorquing their bolts in the correct sequence will temporarily fix a leak, but ultimately a dry or cracked gasket will need to be replaced.

Modern vehicles use plastic instead of metal for valve covers and pans, so be extra careful when working around these parts. If the valve covers or pans are cracked, do not attempt to repair them; replace them with the correct replacement part(s).

5. Change engine oil and filter; reset oil life monitor.

Modern car engines generally require oil changes at 5,000 mile intervals and higher. Follow the schedule in the owner's manual, which is based on the type of driving done. When changing the motor oil on a vehicle, try to do it when the engine is warm. This ensures that the used oil will drain more quickly and thoroughly.

Remove the oil fill cap and the oil drain plug to drain the used motor oil into a drain pan. While the old oil is draining, remove the used oil filter with the appropriate filter socket or strap wrench. Be sure the old filter gasket is removed and clean the filter gasket surface with a lint free cloth. Add fresh oil to the new filter and apply a light coating of motor oil to the gasket before installing it. Tighten the oil filter firmly by hand. Using a new gasket, replace the oil pan drain plug. Put the recommended type and amount of oil into the engine as per the OEM maintenance schedule. If applicable, reset the oil change reminder in the driver's information center display.



The filter should be changed whenever the oil is changed. Make sure you drain and recycle used oil filters in an 'environmentally friendly' manner.

6. Inspect and test radiator, heater core, pressure cap, and coolant recovery system; determine needed repairs; perform cooling system pressure and dye tests.

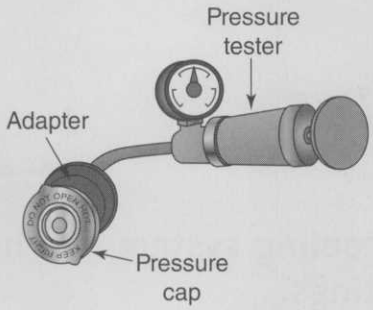
It is important to periodically inspect and test the cooling system for leaks and for pressure holding capability. When the cooling system is being flushed and the coolant is being replaced, it is a good time for such service. Use a radiator/radiator cap tester with the proper adaptor to pressurize the cooling system (only when cool) and determine if any

leaks exist. Test the cap to ensure the cap is holding, and relieving, pressure properly. Do not over-pressurize the system, but do look for signs of falling pressure, which would indicate a leak.

Check for telltale residue left around the upper and lower chambers of the radiator and elsewhere. Check for a loss of (typically green or orange) coolant at the evaporator drain hose under the vehicle, which would indicate a leaking heater core. Some coolant recovery bottles remain pressurized during hot engine operation, so check the plastic recovery bottles for leaks as well.

If a coolant leak is elusive, ultraviolet dye can be added to the cooling system, after which the system is inspected using a UV lamp.

> *Note:* Coolant may also leak into the intake or exhaust system if a cylinder head or engine block is cracked. In these cases, an abnormal amount of white smoke may be seen coming from the exhaust pipe.



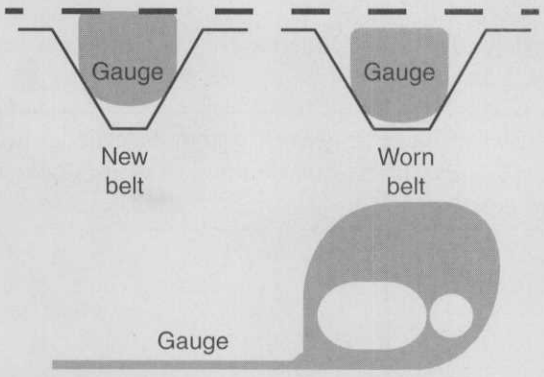
7. Inspect, replace, and adjust drive belt(s), tensioner(s), and pulleys.

There are numerous "V" type and serpentine belts used under the hood of today's vehicles. Such belts do not last forever. During a vehicle inspection, check them for cracking, splitting, dryness, and wear. Serpentine belt manufacturers tell us that modern belt composition does not show the usual signs of dryness and cracking as belts age. The proper way to test serpentine belts is by using a wear gauge (see image).

When replacing a belt, make sure it is properly routed by following the diagram found on the radiator shroud or the underside of the hood. Also be certain the grooves of a serpentine belt are properly set in the pulleys.

Proper belt tension may be established automatically by a belt tensioner, or in some cases, the tension must be set by the technician using a belt tension gauge or another method such as checking deflection with a ruler.

A noisy or squealing belt may need adjustment or replacement. A tensioner or pulley that is noisy may be a part that is waiting to fail. Replace such parts as soon as possible to avoid an inconvenient breakdown. Some tensioners are especially designed to take up and release tension as the belt rotates, so make sure the proper replacement part number is ordered and installed by comparing the old part with the replacement part.



Today's serpentine belts do not always look worn, but still need to be periodically checked. Use a serpentine belt wear gauge like this to determine if the belt is still good.

8. Inspect and replace engine cooling system and heater system hoses, pipes, and fittings.

Engine cooling system and heater hoses do not last forever. Some maintenance schedules call for periodic replacement of hoses even if the parts do not appear worn or ready to fail. Never attempt to replace hoses when the engine is hot! Open the radiator drain cock or loosen a lower radiator hose to drain the system enough to remove and replace the needed hose. Be sure to catch all used coolant in a pan and recycle it.

Route heater hoses the way the OEM intended. They should not be too long or too short. Heater hoses must not be allowed to rest on hot engine components. Some heater systems use metal pipes or specially shaped fittings. Be sure to replace these with OEM or equivalent parts rather than with makeshift or leftover parts.

9. Remove and replace engine thermostat and coolant bypass.

Sometimes a thermostat will fail and not allow the engine to warm up (they usually fail open). In some cases a failed thermostat will cause the MIL to illuminate because some OBD II monitors will only run when the engine is fully warmed up. Only replace a thermostat with an OEM or equivalent part. When installing it, be certain it is positioned properly and seated correctly with the weep hole or jiggle valve upwards. Use a new gasket held in place with a THIN coating of sealant to hold it in place while installing the housing bolts.

Bypass hose replacement may be performed. When replacing them, use OEM or equivalent replacements wherever possible to avoid problems with kinking for deforming.

10. Inspect and test coolant; drain, flush, and refill cooling system with recommended coolant; bleed air as required.

Inspect the coolant for rust, scale, corrosion, and other contaminants such as engine oil or automatic transmission fluid. If the coolant is contaminated, the cooling system should be drained and flushed. If oil is floating on top of the coolant, the engine block or head may be cracked, or the automatic transmission cooler may be leaking. (This condition also means there is coolant in the transmission!) If the vehicle has an external engine oil cooler, it may also be a source of oil contamination in the coolant.

Engine coolant consists of antifreeze and water, typically in a 50/50 mix. The antifreeze content may be tested with a hydrometer, to measure the coolant's specific gravity which indicates the ratio of water to antifreeze. The freezing point of the coolant is indicated on the hydrometer float. The OEM-specified antifreeze content must be maintained in the cooling system.

There are various chemical compositions of antifreeze specified by the OEMs for their vehicles, and they should not be mixed or used in incorrect vehicles. The color of the antifreeze (green, yellow/orange, etc.) helps to identify the type of antifreeze. Check your specifications before adding antifreeze to the vehicle cooling system.

Some vehicles may need to have their cooling system vented of air once the system is filled. This may be as simple as opening a vent screw or slightly raising one side of the vehicle with a floor jack in order to purge air from the system. Follow specific OEM procedures to eliminate air pockets.

11. Inspect and replace accessory belt driven water pumps.

Some vehicles use electric water pumps, but most vehicles still use belt-driven water pumps. These pumps will eventually fail with high mileage due to leaking seals or worn bearings. Check for a noisy pump or for coolant dripping from a belt-driven pump, which indicates the pump's bearing or seal is failing.

Older vehicles use a V-belt to drive the water pump from the crankshaft pulley. Most contemporary vehicles drive the water pump either by a crankshaft-driven serpentine belt or toothed timing belt. Carefully inspect the drive belt for excessive tightness or looseness, wear or deterioration. Something as simple as a failed water pump belt or broken belt will quickly disable a vehicle and possibly contribute to serious internal engine damage.

> *Note:* Since in some vehicles removal of the timing belt must be done to get to the engine-driven water pump, the water pump is often changed routinely during a timing belt replacement to save repeated work later should the old pump fail.

12. Confirm fan operation (both electrical and mechanical); inspect fan clutch, fan shroud, and air dams.

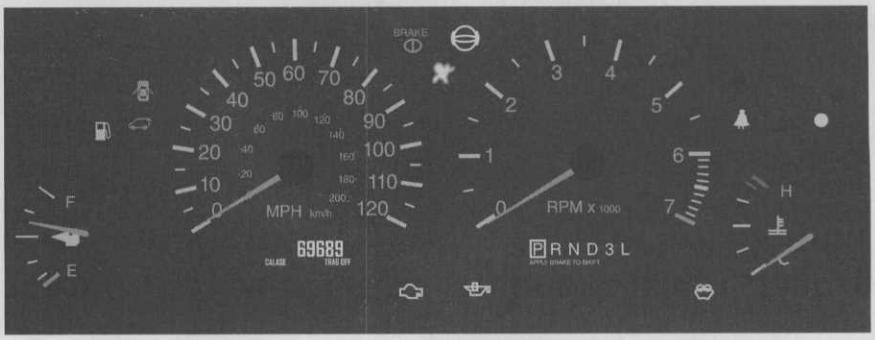
The engine crankshaft-driven cooling fan on older vehicles uses a thermostatic clutch to help reduce noise and parasitic horsepower loss when the fan is not needed. Check that the clutch is firm and not dripping oil. The fan also relies on shrouding to help direct ram air through the radiator and through the fan blades even when the vehicle is stationery. Check that the shrouding has not been damaged or removed. Check that the air dam in

front of the vehicle has not been damaged or torn off from careless parking habits (against curb stops) or from driving off road.

The same applies to electrically driven and thermostatically controlled fans. Make sure they are properly shrouded and check that the fan operates when the air conditioning is turned on or when the engine is idling and fully warmed up.

13. Verify operation of engine-related warning indicators.

There are various dash instruments and warning lights on the instrument cluster that alert the driver of undesirable or unsafe conditions. Many of these indicators are self-tested whenever the vehicle is started, but the vehicle inspection should include making sure all of these indicators are working properly. For vehicles with instruments for the alternator, water temperature, and oil pressure, make certain they read normally. If "idiot lights" are used in place of the voltmeter/ammeter, oil pressure, and coolant temperature gauges, make certain they function as they should. Check the vehicle owner's manual to determine which lights and gauges are included on the instrument panel cluster for indicating abnormal engine conditions.



Verify that all warning lights and indicators work as they should when the ignition is first turned to ON.

14. Perform air induction/throttle body service.

After many miles, oil and dirt can accumulate in the induction system despite a properly maintained intake system air filter. Accumulations of carbon can build up on the throttle body and even cause the throttle plate to stick. The PCM actuated idle-air control motor (IAC) can become clogged with carbon and sticky residue from the PCV system and cause an upset or surging of the engine's idle speed. Remove the air cleaner and inspect for impurities in the intake; check for a sticking throttle plate as it rests on the throat of the throttle body.

Use only OEM-approved cleaning methods, especially when spray cleaning the intake with solvents. The wrong chemical could ruin the mass airflow sensor (MAF) or other sensitive sensors.

Make certain the throttle and cruise control cables operate smoothly, or that the wiring for the drive-by-wire circuitry is not damaged or faulty in any way. Rodents have been known to nest under the warm hood and feast on such wiring harnesses.

15. Inspect, service, or replace air filter(s), filter housing(s), and air intake system components.

Any routine inspection and maintenance program includes the periodic replacement of the air filter. While the filter is being inspected or replaced, inspect the air box for debris such as leaves and insects. Inspect the wiring used for intake air or battery temperature sensors, and make certain the intake duct clamps are snug and the tubing is not cracked, allowing "false air" or unfiltered air to be admitted into the engine. Inspect and clean or replace the PCV filter in the air box as well.

16. Inspect and replace crankcase ventilation system components.

Make certain the filter in the air filter box is clean. Make certain the PCV tubing leading from the PCV valve to the throttle body is not cracked or broken. If the PCV tubing is cracked or broken, it would admit unfiltered air into the intake system.

Remove and shake the PCV valve to make certain it "rattles." If it does not, clean it with solvent or replace it. If there are oil leaks around the valve cover's PCV tubing, inspect for dry or cracked fittings and replace them as needed.

17. Inspect exhaust system for leaks; check hangers, brackets, and heat shields; determine needed repairs.

Today's vehicle exhaust systems last an amazingly long time because stainless steel components are being used by the OEMs for exhaust system components. Still, they should be inspected at every opportunity. With the engine running at idle, hold a shop rag tightly against the exhaust pipe outlet and listen for any "puffing" or leaks of exhaust from the exhaust plumbing or components.

When the car is on the lift, check for exhaust component damage from road debris or from driving off-road. Tap on the exhaust system with a screwdriver and listen for thin or rusted areas which do not "ring" as metal pipes should. Inspect for loose, torn, or missing exhaust pipe hangers and brackets. Physically shake the exhaust system to make sure components are not striking the suspension, drive train, or other undercar parts.

Check that the catalytic converter is in place and that the heat shield is not missing, damaged, rusted through, or loose. Check for rusting or holes in the muffler, resonator, converter, and piping.

Finally, check that the wiring for the pre- and post- CA[illegible] is in good shape.

18. Retrieve and record diagnos[illegible] (DTCs).

This part of the inspection process is the f[illegible]
into the PCM data stream to see what i[illegible]
software for the vehicle under inspe[illegible]
tool. Follow the respective scan too[illegible]
stored that might indicate past re[illegible]

If the MIL remains illuminated[illegible]
active/stored codes—DO NO[illegible]
the diagnostic technicians on s[illegible]
illuminated, and to facilitate t[illegible]

[illegible] sensors

[illegible]stic trouble codes

[illegible]un part; that is, when the MLR technician tap[illegible]
[illegible]s really happening. Using the proper scan tool and
[illegible]tion, connect to the DLC and power up the scan
[illegible]l instructions to determine if any history codes are
[illegible]pairs or future failures.

[illegible] after the engine is started, retrieve and write down the
[illegible] erase them. Both the active and historic codes will help
[illegible]taff to determine the root cause(s) for the MIL to be
[illegible]he needed repairs.

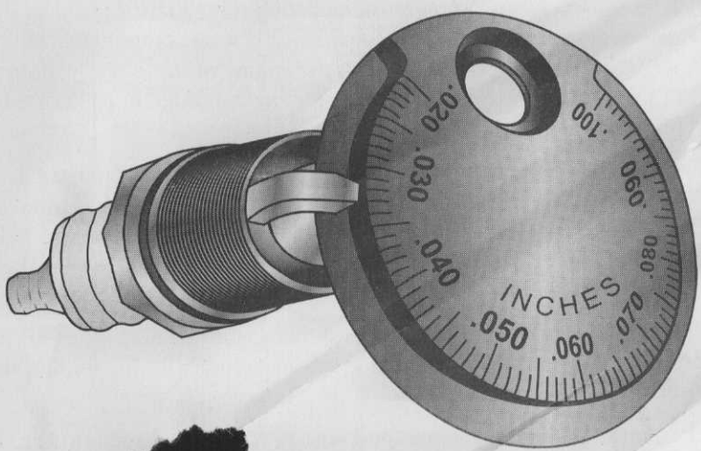
19. Remove and replace spark plugs; inspect secondary ignition components for wear or damage.

Though spark plugs last far longer than they used to before unleaded gasoline, maintenance schedules still call for replacing the spark plugs at specific intervals—as much as 100,000 miles. At that point, plugs can be difficult to remove, and may require special removal techniques to avoid stripping the threads out of the cylinder heads.

Be sure to check for TSBs before determining to "get them out" (literally at any cost). When replacing plugs, it may be wise to use the OEM brand and type to avoid potential DTCs being set later. Use the proper gapping tool to check/set the spark plug gap to specification, and use the proper wrench to avoid breaking the insulator during the installation. Coil over plugs have made failures due to moisture and dirt less frequent compared to when ignition cables were used, but they too need to be inspected for possible wire fraying or damage.

If the vehicle has distributorless ignition, make sure the primary wiring is secure and that the secondary wires are clean and free of wear. If they appear dried or cracked, replace them as a set with good quality replacements.

If the car is equipped with an ignition distributor, inspect the cap inside and out, and inspect the rotor for corrosion or burn marks. Look for signs of oil inside the distributor, which would indicate a leaking distributor seal, and look for electrical arcing on the inside of the cap, which means it needs replacing.



Use a g the spark plug gap is set correctly
befor plugs. Some vehicles are sensitive
so it may be best to stick with
potential problems.

k, fuel cap, lines, fittings, uel filter.

n OBD II vehicles, the MIL will be
r the car, inspect the fuel tank for signs of
ck and the cap's seat for damage that

apping tool to be sure
e installing replacement spark
to the brand and type of plugs used
the OEM recommended plugs to avoid

20. Inspect fuel tank, filler nec and hoses; replace external f

If the fuel system is leaking vapors in any way o
illuminated for an EVAP system leak. From unde
rusting, damage or leaks. Also inspect the filler ne

would allow vapors to escape to the atmosphere. Inspect the cap to make certain the "O" ring is intact. Check for loose or split EVAP hoses; check for leaks at the external fuel filter and all fuel fittings.

If replacing the external fuel filter, follow the OEM instructions to the letter. A special tool may be required to remove the filter fuel line clamps. Catch any fuel spills in a rag, and make certain the replacement filter is installed facing the correct direction for fuel flow, as is customarily indicted by an arrow pointing towards the engine/outlet side of the filter.

21. Inspect canister, lines/hoses, mechanical and electrical components of the evaporative emissions control system (EVAP).

Inspect all electrical, vacuum, and fuel line connections to EVAP components. As mentioned above, the EVAP system is monitored by the OBD II system. Even minor EVAP leaks will be detected and trip a fault code (a DTC). When this happens, first check that the fuel cap is properly installed on the filler pipe. Second, check for loose or cracked flexible hose/tubing around the fuel canister and other EVAP components both under the hood and under the car. For difficult-to-find EVAP leaks, a "smoke machine" can be used to very slightly pressurize the fuel system with smoke and UV dye. Any leaks will be found where the smoke escapes or leaves a UV sensitive trace of powder.

22. Check and refill diesel exhaust fluid (DEF).

Today's diesel vehicles employ a variety of emission control devices that were unheard of just a few short years ago. One of these is the treatment of NOx through the use of special urea-based fluid injected into the exhaust stream. Selective catalytic reduction (SCR) is used to reduce the amount of NOx released into the air by using the diesel exhaust fluid (DEF) to turn smog-forming NOx into harmless nitrogen and water.

The blue-colored fluid is added periodically to a special container on board the diesel vehicle, and is automatically injected by the computer-controlled emission system. If the fluid runs low, the driver is warned, and if the container becomes seriously low, the engine is de-rated of power to make certain the driver gets the message.

Routine maintenance or inspection of a late model diesel vehicle would certainly include checking and filling as needed the blue-capped DEF container with urea fluid sold by any number of distributors. DEF is sometimes marketed by German OEMs under the name AdBlue®.

B. Automatic Transmission/Transaxle (4 questions)

1. Road test the vehicle to normal operation; retrieve and record diagnostic trouble codes (DTCs).

Unusual automatic transmission noises or smells may be evident and even obvious with the car parked in the shop. Likewise, it is obvious when the car will not move forward in LOW or DRIVE, or backwards in REVERSE. In many cases, however, it would be difficult to verify a customer's concern about the automatic transmission's performance in a vehicle without taking it for a test drive.

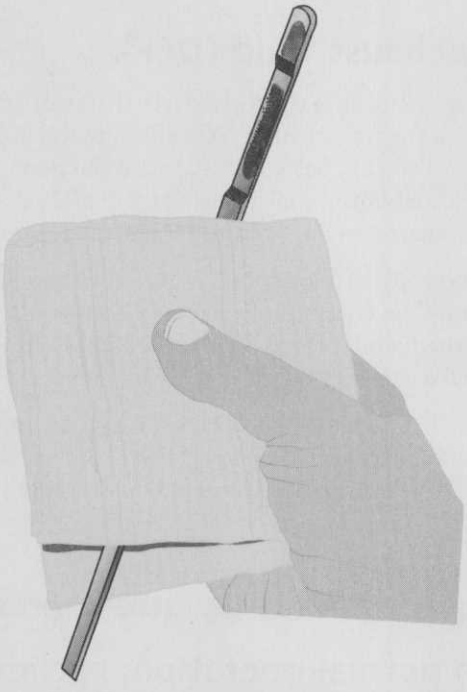
While on the road, listen for whining of the pump, be alert for harsh up or downshifting, and determine if shifting occurs at the proper time for given speeds and loads. Perhaps a simple adjustment is all that is needed. On the other hand, it may be that something is broken, causing the transmission to only move forward in LOW, or perhaps the transmission stays in "LIMP" mode.

Let the diagnostic capability of the TCM help determine a troubleshooting strategy. Take careful note of any unusual operation, and once back in the shop, retrieve and save any stored codes in the Transmission Control Module (TCM). To save time and effort, refer to the diagnostic "trouble trees" in the vehicle service manual to determine the proper diagnostic strategy to follow.

2. Determine fluid type, level, and condition.

Pull the dipstick and smell the fluid. Does it smell bad or burnt? How is its color? Is it red as it should normally be, or is it a dirty brown in color? Is the fluid level correct for the temperature at which it is checked? Automatic transmission fluid expands as it gets warm, so do not make the mistake of adding ATF when it is not needed.

Check the level with the vehicle on a level surface and with the A/T warmed up.If the fluid smells burnt, the internal bands and/or clutch surfaces may be burnt, requiring a transmission rebuild or replacement.



Check the transmission fluid level while hot; also check to see if it smells burnt.

3. Inspect transmission for leaks; replace external seals and gaskets.

If the ATF is found to be low, check for leaks at the transmission pan gasket. If a transmission pan gasket is in good condition, some OEMs advocate reusing the gasket more than once. Some OEMs advocate using special sealant rather than a gasket. When using sealant, use it sparingly and make certain it is placed along the outside of the pan's bolt holes to minimize the possibility of sealant getting into the transmission itself.

4. Inspect and replace CV boots, axles, drive shafts, U-joints, drive axle joints, and seals.

Today's front-wheel-drive vehicles often use MacPherson strut design front ends. These rely on constant velocity joints (CV) joints to enable the front wheels to turn sharply and yet drive smoothly without jerkiness or inconsistent torque. Over time, the boots that protect the inner—and especially the outer—CV joints may crack or become torn, allowing water and dirt to contaminate the CV joint inside. Once this happens, it is only a matter of time before the joint fails.

A leaking CV joint boot can be evident due to traces of lubricant splattered on the suspension components nearby. If caught in time, a replacement boot can be installed without disassembling the joint itself, or the driveshaft (half-axle) can be removed from the vehicle and the joint rebuilt. Sometimes it is easier and less expensive to replace the entire axle shaft assembly with a rebuilt unit that includes the inner and outer CV joints.

For rear-wheel-drive (RWD) and four-wheel-drive (4WD) vehicles, driveshafts and drive axles use universal joints for transferring torque at ever-changing angles. These require periodic inspection. Check driveshafts and U-joints for signs of rust, meaning a lack of lubricant. Also check for U-joint needle bearing failure, evident by rust, looseness and play in the joints themselves. When replacing driveshafts, be sure to reinstall them with the same orientation (phasing) as when they came out.

Check transmission/transaxle half-axle seals and output shaft seals for leaks. If they are leaking, check for excessive internal bearing play or for a plugged transmission breather. Replace worn or faulty components as needed.

5. Visually inspect condition of transmission cooling system, lines, and fittings.

A routine undercar inspection includes looking for leaks at the transmission cooler, the cooler lines, and fittings. ATF hoses must allow for engine/transmission movement and may over time become soft and porous. Check for signs of transmission fluid dripping on the floor. Replace components as needed.

6. Inspect and replace power train mounts.

The engine and transmission assembly need to be able to rock with torque reversals associated with accelerating and coasting. This ability is provided by flexible motor and transmission (aka powertrain) mounts. Over time, vehicles tend to drip oil or fluids down onto these mounts, and oil has an especially adverse affect on the flexible rubber used in them.

Check powertrain mounts for swelling or deterioration. Having an engine come loose in a vehicle is obviously not a good thing, and may be evident by the transmission jumping out of gear. Raise the engine or transmission slightly with a jack to determine if the mounts have separated. Replace them if necessary.

7. Replace fluid and filter(s).

Until recently, OEMs have advocated periodic replacement of the automatic transmission filter, especially if the vehicle is used in dusty environments. In many cases, this requires dropping the transmission pan to get to the filter. Since there is likely no drain plug on the A/T, be careful when removing the pan bolts to avoid a major spill onto the shop floor—or on yourself! The pan should only be removed where the environment is free of dirt and dust and the surrounding air is still (no fans blowing). Getting dirt inside the transmission's fine internal moving parts could be worse than living with a dirty transmission filter. While the pan is removed, remove any fine metal particles from the collecting magnet in the pan. Thoroughly clean and dry the pan, and if used, replace the gasket. Tighten the bolts hand tight, then torque them in the proper sequence. Add new ATF as needed to the transmission, making sure it is the proper type. Also be sure to leave some room for fluid expansion once it is warm.

> *Note:* Some contemporary vehicles do not have a means for checking fluid level or replacing a filter. Unless there is a leak, the A/T is deemed to be a maintenance-free component. Always check the OEM service procedures before attempting transmission service.

C. Manual Drive Train and Axles (6 questions)

1. Inspect, adjust, replace, and bleed external hydraulic clutch slave/release cylinder, master cylinder, lines, and hoses; clean and flush hydraulic system; refill with proper fluid.

Many newer vehicles are equipped with a hydraulically actuated clutch (these systems typically use brake fluid). If the clutch does not engage or disengage as it should, check for leaks. Hydraulic clutches with a constant-running release bearing do not require adjustment. Check the system for low fluid or for air in the system. If the fluid level is low, inspect the system for leaks. If fluid is leaking from the master cylinder or slave cylinder, overhaul or replace them as required. If fluid is leaking from the line between the master cylinder and slave cylinder, repair or replace the line.

If air has gotten into the system, check that all fittings are snug. Bleed any air from the hydraulic clutch system, which is similar to bleeding a brake system, by following the vehicle manufacturer's procedures. If the system has been contaminated with the wrong fluid, drain and flush the hydraulic clutch system and fill it with the approved fluid (normally brake fluid) to the correct level.

> *Note:* If the vehicle has a clutch actuated by a cable or linkage, inspect the self-adjusting cable mechanism and /or linkage for wear or damage. If an out-of-adjustment condition exists, adjust the linkage for proper clutch pedal free play.

2. Inspect and replace power train mounts.

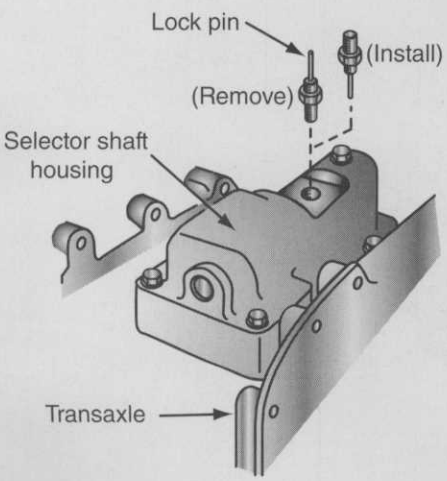
As mentioned in Task B.6, the engine and transmission assembly need to be able to rock with torque reversals associated with accelerating and coasting. The ability for this is provided by flexible powertrain mounts. Refer to Task B.6 for inspection and servicing instructions.

3. Inspect, adjust, and replace transmission/transaxle external shifter assembly, shift linkages, brackets, bushings/grommets, pivots, and levers.

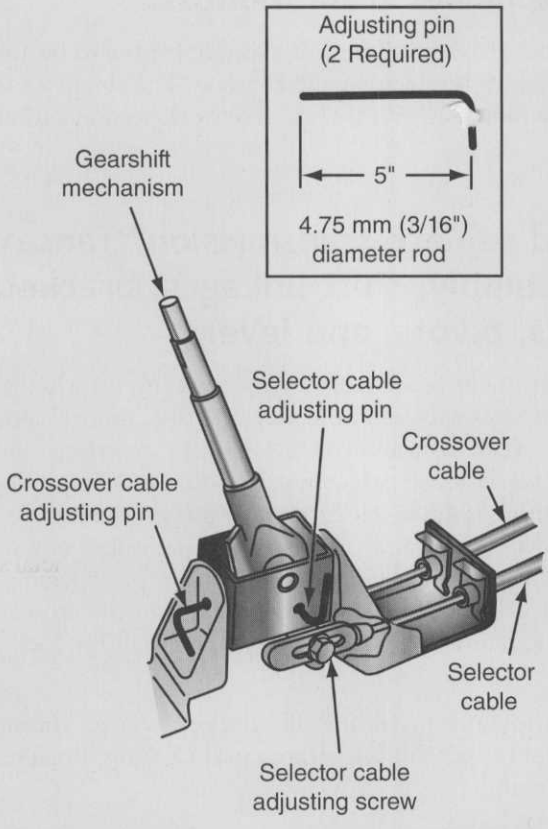
The shift linkage or cable adjustment procedure varies depending on whether the transaxle has shift cables or linkages and upon the vehicle make, model, and year. Making the adjustment on a certain vehicle involves removing, reversing, and reinserting the lock pin from the transaxle selector shaft housing. The pin locks the 1–2 shift fork shaft in the neutral position. Next, remove the gearshift knob and console. Then, loosen the selector cable and crossover cable adjusting screws and install a 3/16-inch (4.75 millimeter) drill bit into the adjusting pin openings for each cable. Now, tighten the selector screws on the selector cable and the crossover cable to the specified torque. Finally, remove the adjusting pins, reinstall the lock pin, and install the console and gearshift knob.

Start the engine, fully depress the clutch pedal, and shift the gear selector through all the gear positions while checking for proper shifting without gear clashing. Road test the vehicle and check for proper shifting.

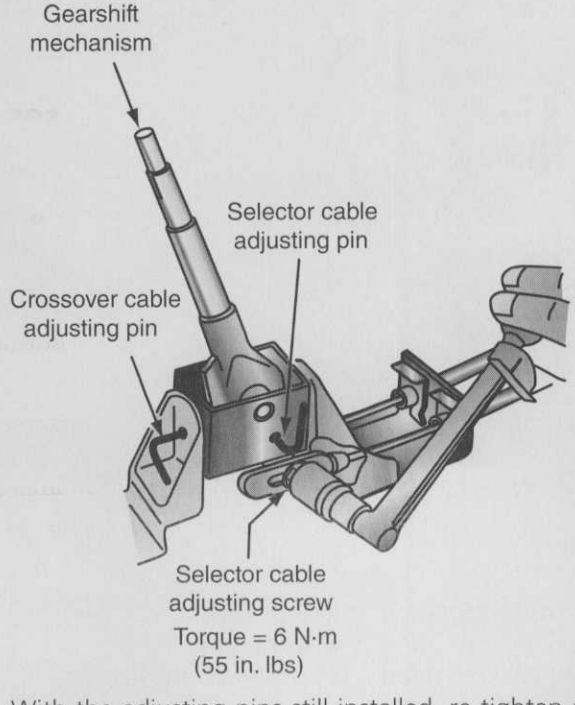
The shift linkage or cable adjustment procedure varies depending on whether the transaxle has shift cables or linkages, and upon the vehicle make, model, and year. Making the linkage adjustment may involve removing, reversing, and reinserting a lock pin from the transaxle selector shaft housing.



Before making adjustments to the crossover and gear select cables on a manual drivetrain vehicle, some vehicles require that the shift mechanism be locked in neutral. To do this, remove the gearshift knob and console; then remove, reverse and re-install the selector housing lock pin, as shown here.



Next, loosen the two cable adjustment screws and insert a **3/16**" (**4.75** mm) "adjusting pin" into each of the two adjusting pin openings, as shown here.



With the adjusting pins still installed, re-tighten and torque the cable adjusting screws to specifications; then remove the adjusting pins, reverse the lock pin to its original position, and re-install the console and gearshift knob.

4. Inspect and replace external seals.

Check the rear main seal of a RWD vehicle for leakage of transmission lubricant. If leaking, check for a worn tailshaft bearing by pushing the drive shaft U-joint up, down, and sideways while observing lateral movement of the tailshaft. If movement is noticed, the rear main bearing may be worn and should be replaced along with a new rear seal. If a FWD transaxle is leaking at the half shafts, use the same procedure to check for bearing wear. Replace the axle bearings and seals if needed.

Check for transmission fluid leaking from the clutch housing. If leaking is detected, remove the inspection plate, if provided, and check for oil from a failed input shaft bearing seal (or a rear main engine oil seal). (Check for an oil-contaminated clutch disc at the same time.)

Also check the transmission cover plate gasket and shift linkage seals for signs of oil leaking. Replace as required. Check for a plugged transmission vent, which could cause internal pressure to force oil past the seals.

5. Check fluid level; refill with fluid.

To check for correct lubricant oil level in a manual transmission, look for a metal screw-in plug, a dipstick, or some other means of gaining access to the transmission lubricant. At least one OEM requires that the speedometer drive gear be removed for checking the manual transmission oil level. Make sure the car is level when checking the fluid level. Remove the side plug and make sure the lube is close to, or at, the level of the threads in the case. Unless there has been a leak, transmission fluid should be up to the level of the fill hole.

Add fluid, if needed, following the OEM procedures. Use the recommended lubricant as specified by the OEM. Some vehicles call for 75/80 or 80/90 weight lubrication oil, and one OEM calls for 30 weight motor oil in their manual transmissions. Check the specs to be sure.

Drive Shaft, Half-Shaft, and Universal Joints/Constant Velocity (CV) Joint (Front and Rear Wheel Drive)

6. Road test the vehicle to verify drive train noises and vibration.

The best way to determine is there is a problem in the drive train is to test drive the vehicle. Make sure there is no unusual vibration or noise when accelerating, decelerating or when turning on dry pavement at medium and very low speeds (~10 mph). Clicking or clunking noises may indicate worn U-joint or CV joint issues. Determine if any noticeable vibration stops when coasting at different speeds in neutral. This will help isolate tire and wheel issues related to imbalance, wear or defects from drive train concerns.

When a bearing is wearing out, it usually makes a clicking or howling noise as it rotates. The amount of noise depends on how much load is placed on it. Turns place additional thrust loads on wheel bearings so listen for front-wheel bearing noise when the vehicle is turning a corner.

A defective rear axle bearing noise is more noticeable at lower vehicle speeds when decelerating because there is less engine noise to mask it. You can diagnose rear axle bearing noise with the vehicle on a lift with the engine running and the transmission in drive. Run the vehicle at 35 to 45 miles per hour (56 to 72 kilometers per hour) and use a stethoscope placed on the rear axle housing directly over the axle bearings to listen for unusual noise. Noises, such as grinding or clicking, mean the bearings should be replaced. When a bearing fails, there is always a reason. The technician must correct the cause of failure to prevent the new bearing from failing.

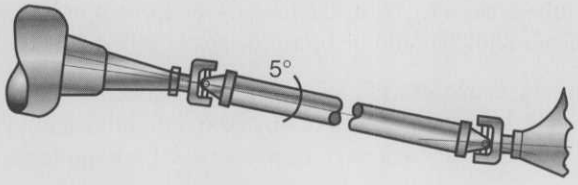
7. Inspect, service, and replace shafts, yokes, boots, universal/CV joints; verify proper phasing.

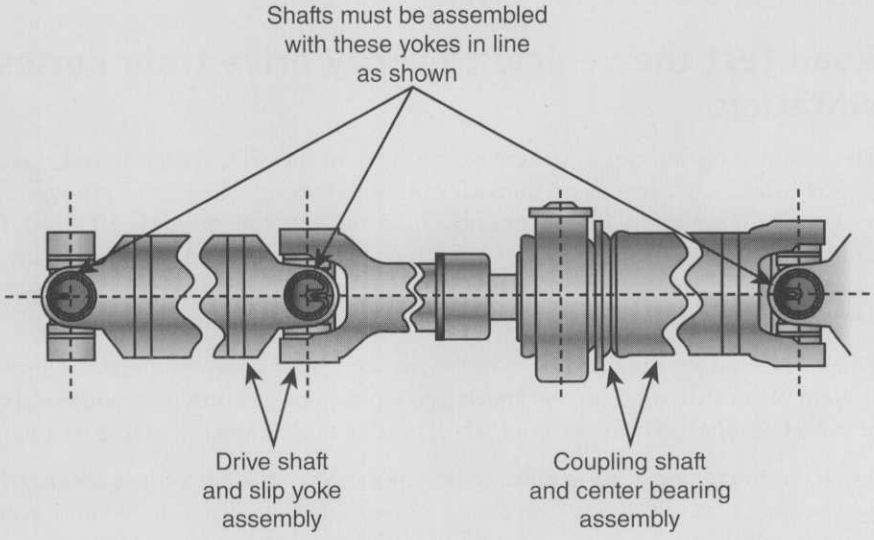
When performing an undercar inspection on a RWD, AWD, or 4WD vehicle, check for loose driveshaft(s), universal joints, and yokes. Grasp each drive shaft and check for vertical movement in the universal joint. Try to rotate each drive shaft by hand and watch for movement between the driveshaft and the yoke. If vertical or rotary movement can be seen, replace the U-joint. Inspect the drive shaft for damage such as dents or missing balance weights.

For FWD vehicles, check the inner and outer CV joints for looseness or wear during the road test by listening for clicks during slow tight turns. Inspect inner and outer boots for cracks or leaks. Refer to Task B.4 for further information. Split-type replacement CV joint boots can be installed without removing the drive axles (half shafts).

Phasing of drive shafts involves making sure the universal joints are working in harmony. U-joints on the same driveshaft should be on the same plane, meaning they are in phase with each other.

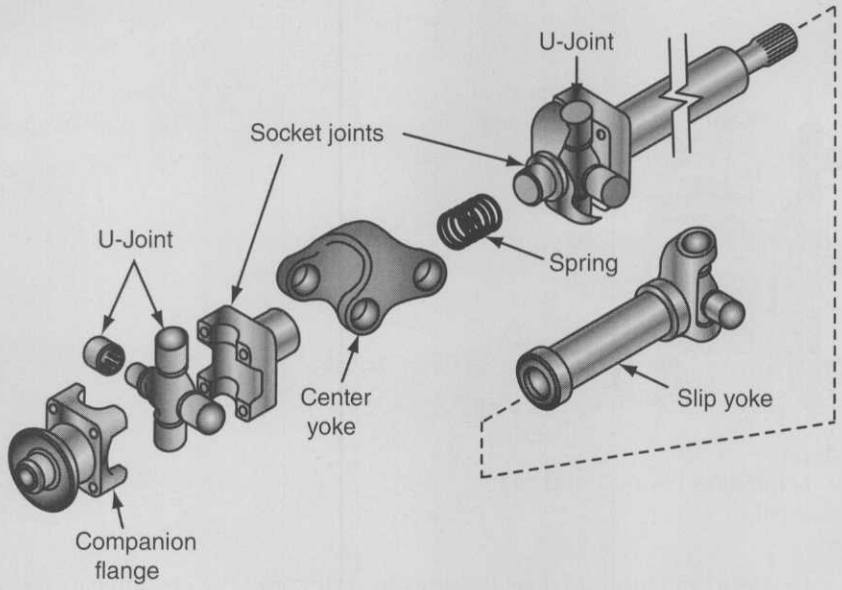
When under the car, be sure to examine the CV joint boots for splits or cracks. Replace any boots that show signs of leakage ASAP to prevent possible CV joint damage.

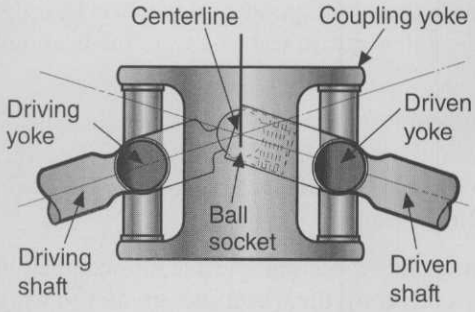




8. Inspect, service, and replace drive shaft center support bearings.

Some rear-wheel-drive vehicles have double (Cardan-type) universal joints mounted close together with a center yoke which connects the two universal joints and "splits the angle" between them. As described in Task C.7, check the U-joints and yoke for looseness. Replace any defective driveshaft support bearings or parts.



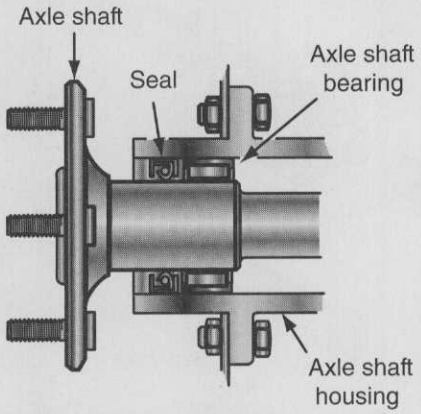


9. Inspect, service, and replace wheel bearings, seals, and hubs, excluding press-type bearings.

When a bearing fails, there is always a reason. The technician must correct the cause of a bearing failure to prevent the new bearing from failing. When a bearing is wearing out, it usually makes howling noise as it rotates. The amount of howling depends on how much load is placed on it.

A front wheel bearing usually provides a more noticeable howl when the vehicle is turning a corner because this places additional thrust load on the bearing. A defective rear axle bearing will usually make a howling noise that is more noticeable at lower vehicle speeds and when decelerating because there is less engine noise.

Diagnose rear axle bearing noise with the vehicle on a lift with the engine running and the transmission in drive. Run the vehicle at 35 to 45 miles per hour (56 to 72 kilometers per hour) and use a stethoscope placed on the rear axle housing directly over the axle bearings to listen for unusual noise. Noises, such as grinding or clicking, mean the bearings should be replaced.



Rear axle rolling bearing and seal, rear-wheel drive car.

Remove, clean, and inspect wheel bearings according to OEM maintenance schedules. Once removed, discard the used grease seal. Remove the bearings, wash them in solvent, and dry them with a lint free towel. Inspect the bearings for damage such as galling, abrasion, indentations, or other abnormalities.

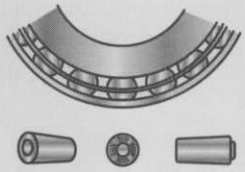
If the bearings are in good shape, repack them with good quality wheel bearing grease. Avoid getting dirt or dust in them. Use a new grease seal whenever the bearings are being serviced or replaced.

If the wheel bearings are an integral assembly with the hub, you can check the bearing end play with the vehicle raised off the ground using a dial indicator. Place the indicator stem against the hub and move the hub in and out. If end play exceeds OEM specs, replace the hub and bearing assembly. Replace the bearing if it is noisy.

When front wheel bearings are mounted in the steering knuckle, inspect them for looseness. With the vehicle off the ground, grasp the wheel and attempt to wiggle it while feeling for play in the hub. If looseness is detected, check the bearings with a dial indicator, and discard them if they are out of specification.

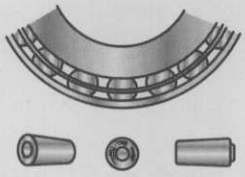
TAPERED ROLLER BEARING DIAGNOSIS

Consider the following factors when diagnosing bearing condition:
1. General condition of all parts during disassembly and inspection.
2. Classify the failure with the aid of the illustrations.
3. Determine the cause.
4. Make all repairs following recommended procedures.



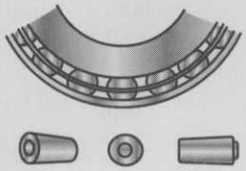
ABRASIVE STEP WEAR

Pattern on roller ends caused by fine abrasives. Clean all parts and housings, check seals and bearings, and replace if leaking, rough or noisy.



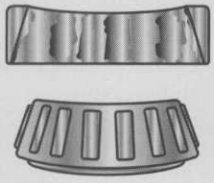
GALLING

Metal smears on roller ends due to overheating, lubricant failure, or overload. Replace bearing, check seals, and check for proper lubrication.



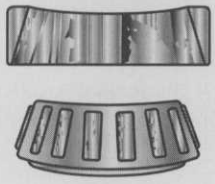
BENT CAGE

Cage damaged due to improper handling or tool usage. Replace bearing.



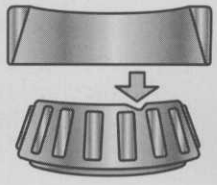
ABRASIVE ROLLER WEAR

Pattern on races and rollers caused by fine abrasives. Clean all parts and housings, check seals and bearings, and replace if leaking, rough or noisy.



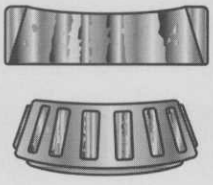
ETCHING

Bearing surfaces appear gray or grayish black in color with related etching away of material usually at roller spacing. Replace bearings, check seals, and check for proper lubrication.



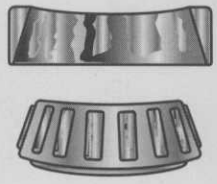
BENT CAGE

Cage damaged due to improper handling or tool usage. Replace bearing.



INDENTATIONS

Surface depressions on race and rollers caused by hard particles of foreign material. Clean all parts and housings. Check seals, and replace bearings if rough or noisy.



MISALIGNMENT

Outer race misalignment due to foreign object. Clean related parts and replace bearing. Make sure races are properly sealed.

Bearing failures and corrective procedures.

Rear Wheel Drive Axle Inspection

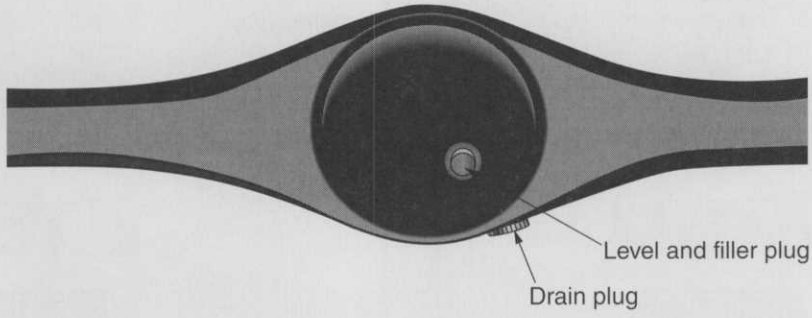
10. Identify fluid leakage problems.

On vehicles with a live (tubular) rear axle, lubricant for the bearings is provided by the lubricant in the differential. With the vehicle on a lift, carefully look for signs of oil or grease on the normally dry and dusty wheels and surrounding suspension components. Bearing failure on a live axle RWD vehicle may allow excessive lateral movement of the axle, which, in turn, would cause the axle seal to leak. When it does, lube oil leaking from the tubular axle housing will possibly contaminate the rear brakes. Also check for leaks at the differential pinion shaft seal and the differential cover. If leakage is evident, check if the differential has been overfilled or if the vent is clogged.

11. Inspect, drain, and refill with lubricant.

Remove the threaded inspection hole plug from the rear cover of the differential, insert your finger, and check for lubricant oil which should be close to the level of the threaded hole. If the oil level is low, try to determine the reason. There could be a leak, or perhaps oil has been thrown from the differential vent hole. If oil spills from the inspection hole, the differential may have been previously overfilled.

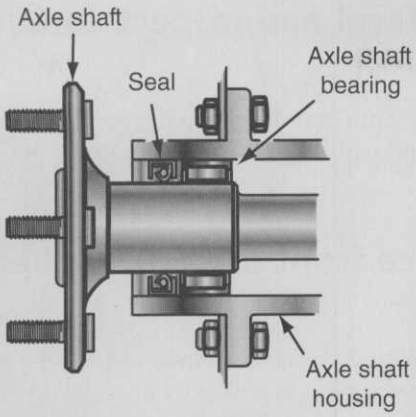
To change the differential gear lube, remove the drain plug and drain the old lubricant. If there is no drain plug, use an oil suction/extraction device. Insert the hose into the differential to draw out as much used gear oil as possible. It helps to do this with the differential at operating temperature. Once drained, install the drain plug and refill the differential to the level of the inspection hole using the OEM recommended type and viscosity of gear lube. Do not overfill the differential. Reinstall and torque the inspection plug to specs.



12. Inspect and replace rear axle shaft wheel studs.

With the rear wheel removed, inspect the condition of the axle flange and wheel studs that hold the wheel in place. Clean the flange with a wire brush to remove any debris or rust. Inspect the threads on the studs. If they are worn or damaged, replace them.

The studs are typically pressed/splined into position from the back of the flange. Install a spare lug nut loosely on a damaged stud and drive it out by striking the nut with a heavy hammer. Install a new replacement stud into the flange from the rear. Place some heavy washers on the stud and thread a good lug nut down onto the washer. Now use a wrench to pull the stud tight into position in the axle flange.



Rear axle with flange and studs, axle bearing, and oil seal.

13. Inspect axle housing and vent; inspect rear axle mountings.

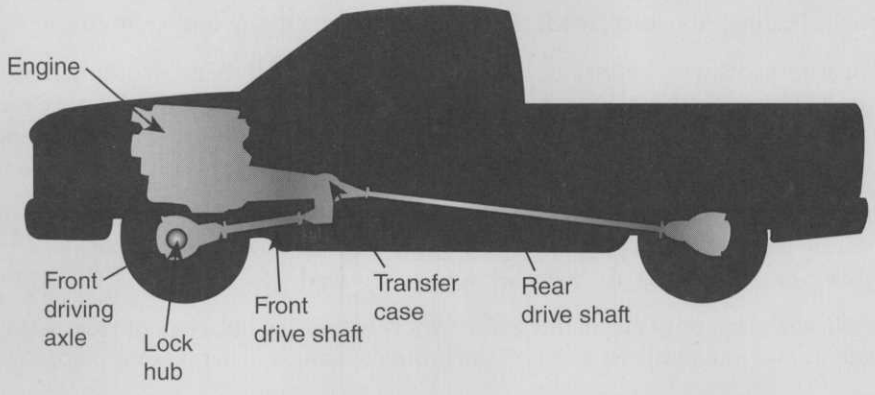
Check the axle housings for damage caused by striking rocks or road debris. Check the axle mounts and related hardware for damage or for being out of their normal position. Check the vent on top of the differential to make certain it is clear.

Four Wheel Drive

14. Inspect, adjust, and repair transfer case manual shifting mechanisms, bushings, mounts, levers, and brackets.

Due to the conditions under which 4WD vehicles operate, they need close periodic inspection of their undercar components. Rocks and other obstacles encountered while operating off-road can cause havoc with drive train components. The transfer case and related parts may be damaged even though they are typically protected by shields from impact by rocks, branches, and other debris.

Check that any undercar shields are where they should be and have not been removed. Look for unusual scrape marks or dents on the shields. Check for bent shift linkage, gearbox mounts and brackets or damaged bushings that would indicate severe off-road driving and the need for repairs.



15. Check transfer case fluid level and inspect condition; drain and refill with fluid.

Remove the plug from the inspection hole in the transfer case and check for the proper level of gear lubricant. Refer to checking and replacing gear lubricant in the differential, as described in Task C.11.

16. Inspect, service, and replace front drive/propeller shaft and universal/CV joints.

A common complaint related to drive shafts and universal joints is a squeaking noise that increases in frequency with vehicle speed. Such noise is typically caused by dry or worn universal joints and is heard best while driving at low speeds. A worn universal joint may also make a "clank" noise when the transmission is shifted from park to drive or into reverse. A severely worn U-joint may emit a "clunking" noise at low speeds. Any of these noises calls for replacing the U-joints.

For troubleshooting CV joints, refer to Task C.7.

17. Inspect front drive axle universal/CV joints and drive/half shafts, axle seals, and vents.

The inspection of front drive U-joints and CV joints is similar to procedures for front- and rear-wheel-drive vehicles described in Task C.7. CV joint boots should be inspected regularly for cracks or tears. Check for loose or damaged clamps because these clamps keep the boots airtight. Check the boots and surrounding areas for splattered grease thrown from the boot.

Axle seals will eventually leak over time and should be periodically checked. If they are found to be leaking, determine the root cause as described in Task C.9.

18. Inspect front wheel bearings, seals, and hubs.

Whether used in front (FWD), rear (RWD) or 4-wheel drive (4WD) vehicles, bearings normally last a long time, so when they fail, look for the reason. Typical causes could be dirt ingestion caused by a faulty seal, water from the bearings being submerged (think boat trailer), or just dry from a lack of maintenance. The technician's job is to correct the root cause of a bearing failure to prevent the new bearing(s) from failing again.

When a bearing is on its way out, it usually makes howling noise as it rotates. The howling depends on how much load is placed on it. A front wheel bearing usually provides a more noticeable howl when the vehicle is turning a corner because this places additional thrust load on the bearing. Also, noises such as grinding or clicking means further investigation is needed.

For serviceable wheel bearings, remove, clean and inspect them according to OEM maintenance schedules. Discard the used grease seal once removed. Remove the bearings and wash them in solvent; dry them with shop air (but do not spin them!). Inspect the bearings for damage such as galling, abrasion, indentations, or other abnormalities.

If in good shape, repack the bearings with a good quality wheel bearing grease using a bearing packing tool if possible. Avoid getting dirt or dust in them. Use a new grease seal whenever the bearings are being serviced or replaced.

If the wheel bearings are an integral assembly within the hub, you can check the bearing end play with the vehicle raised off the ground. Using a dial indicator, place the indicator

stem against the hub and move the hub in and out. If end play exceeds OEM specs, replace the hub and/or the bearing assembly as needed. Replace the bearing if it was noisy.

When front wheel bearings are mounted in the steering knuckle, inspect them for looseness. With the vehicle off the ground, grasp the wheel and attempt to wiggle it while feeling for play in the hub. If looseness is detected, check them with a dial indicator as described above, and discard them if out of spec.

19. Inspect transfer case, front differential, and axle seals and vents.

Check for leaks at the transfer case and front differential seals or gaskets. If an oil pan is used, some OEMs advocate re-using certain pan gaskets; some OEMs advocate using RTV sealant rather than a gasket. When using a sealant, use it sparingly making certain it is placed along the outside of the pan's bolt holes to minimize the possibility of sealant getting into the transfer case itself.

Check any axle seals for leakage of lubricant. If leaking, check for worn drive shaft/axle shaft bearings by pushing the drive shaft/axle shaft U-joint up, down and sideways while looking for lateral movement. If movement is noticed, the bearing may be worn. If so, it should be replaced along with a new seal.

Check the differential vent / breather located on top of the differential or possibly on the axle housing to make certain it is clear. If the vent is plugged, internal pressure buildup may force gear lubricant past solid-axle oil seals and contaminate the brakes.

20. Inspect tires for correct size for vehicle application; check for wear.

For safety reasons, and to ensure proper ABS, TPMS, and electronic stability control system operation, it is important to use OEM-recommended tire sizes on all four corners of the vehicle. If the vehicle owner has elected to plus size the tires or change wheel offset for any reason, the on-board electronic systems may not like the abnormal input signals associated with such modifications. Such modifications can result in the setting of fault codes, illuminated MILs, and a loss of vehicle handling and stability, which are usually provided by these vehicle features.

Likewise, uneven tire wear can cause a similar tripping of codes and the increased likelihood of handling or braking inefficiency, even on smooth, dry roads. 4WD vehicles especially need close tire inspection for damage caused by adventurous off-road driving, vehicle use at unpaved construction sites, or on unpaved washboarded and potholed roads.

Refer to the owner's manual (or specific tire manufacturer specifications) for proper tire size selection.

21. Retrieve and record diagnostic trouble codes (DTCs).

Part of the MLR technician's job is to understand how to use scan tools to retrieve and record diagnostic trouble codes stored in the vehicle's on-board computers. DTCs steer the technician in the right direction when diagnosing abnormal conditions in the vehicle. Once the codes have been retrieved and documented on the repair order, DO NOT erase them. Leave them for the technician assigned to doing the needed repairs to clear, once the vehicle faults have been corrected and the vehicle has been test driven and deemed correctly fixed.

> *Note:* Different manufacturers, and independent suppliers, offer scan tools with a whole variety of features.

While the OEMs provide scan tools that can read proprietary non-emissions-related DTCs, aftermarket scan tools provide features that may not be available on the OEM scan tools. In either case, select the scan tool that provides you with the needed diagnostic features. Scan tools range from simple code readers to bi-directional scan tools that read detailed sensor data (PIDs), put actuators through their paces, replay freeze frame data, access diagnostic and repair data wirelessly from the Internet, and serve to reflash PCMs and other on-board ECUs.

D. Suspension and Steering (13 questions)

1. Disarm airbag (SRS) system.

Service to the air bag system will require disarming/disabling the air bag deployment circuits; otherwise, accidental air bag deployment could occur, causing serious personal injury.

Check the OEM service manual and follow its procedures to the letter before performing any work on the Supplemental Restraint Systems (SRS) to avoid accidental deployment of the system. Technicians are too often injured by accidental air bag deployment.

In general, disabling the front and side (side curtain) air bags requires doing any of these procedures: turning off the ignition, removing the SRS fuse(s), disconnecting various connectors (yellow colored) behind the dash and under the seats. Be sure to wait the required time until the SRS module powers down (5 or more minutes).

2. Check power steering fluid level; determine fluid type and adjust fluid level; identify system type (electric or hydraulic).

Most vehicles use hydraulic power steering systems. Look for a belt-driven power steering pump and reservoir under the hood. Some GM vehicles have a combined hydraulic power steering and power brake systems (called HydroBoost). Some contemporary vehicles are using Electronic Power Steering (EPS) and Variable Effort Steering (VES) systems. Such systems rely on the Vehicle Speed Sensor (VSS) as input to a steering controller that in turn modulates steering pressure according to vehicle speed.

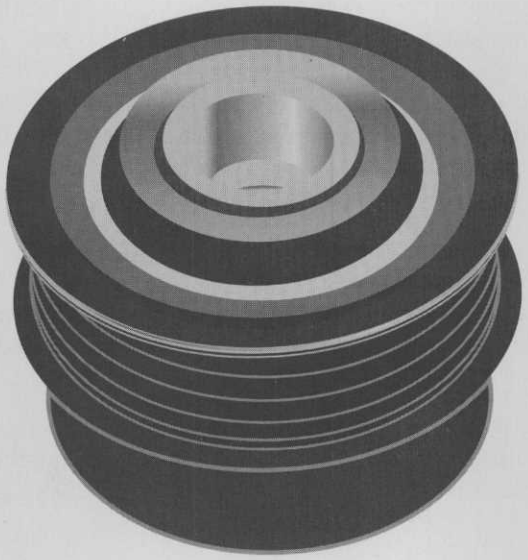
Checking the level of hydraulic power steering (PS) fluid is a regular maintenance item, even though power steering fluid does not normally need to be "topped off." Some vehicle manufacturers recommend checking the fluid level when it is up to operating temperature and the engine is running. Normally, a dipstick on the pump reservoir is used to check the fluid level. To check the fluid level, remove the dipstick, wipe it clean with a lint-free rag or towel, reinsert it, and withdraw it to read the fluid level on the dipstick.

There are different formulas of PS fluid being used in various vehicles, so when adding or replacing PS fluid, be sure to only use the OEM-recommended type of fluid.

Hybrid and battery electric vehicles use electric powered rack and pinion steering for less engine parasitic load (from a PS pump) and improved gas mileage. These systems do need or have a hydraulic PS pump. Watch for an increase of electric power steering systems as new vehicle models appear on the market.

3. Inspect, adjust, and replace power steering pump belt(s), tensioners and pulleys; verify pulley alignment.

Part of a routine maintenance inspection should include checking the power steering pump belt condition and its tension. Check for a shiny belt surface, cracks, splits, and other defects on V belts. On serpentine bests, look for wear using an approved wear gauge.



Some pulleys like this alternator decoupler pulley (ADP) are special because they 'synchronize' the belt drive system for improved engine efficiency to reduce Noise, Vibration and Harshness (NVH) and increase component life. ADPs are not interchangeable, so be sure to use the correct replacement part.

Check belt tension with the engine OFF by pressing down on it between two pulleys. Take note of how much the belt deflects and compare the deflection to specifications. You can also use a belt tension gauge. The belt should be tight, but not too tight. Any squealing when the steering wheel is turned against the left or right lock indicates the belt is too loose or is dried out and needs replacing.

Belts are kept tight as they wear by belt tensioners. Some tensioners have wear indicators to show if the belt has stretched or become worn beyond its service life. Tensioner bearings will make noise as they become faulty and need replacing. Listen for louder than normal "running noise" or whining from the tensioner. Use a piece of hose or tubing as a stethoscope to localize belt tensioner or pulley noises, being ever mindful of possible entanglement with moving engine parts.

A variety of tensioner types are used on contemporary vehicles. Some overrun to reduce parasitic engine losses, improve vehicle mileage, and reduce emissions. Some even help smooth out torque reversals from the crankshaft pulley, which would affect the belt-driven accessories. Make certain the correct style of tensioner is installed when replacing the belt tensioner.

A serpentine (ribbed V) belt routing diagram sticker should be affixed to the radiator cowling or on the underside of the hood. Check that the ribbed portion of the belt is properly seated in all pulleys and not offset by one or more ribs. With the engine OFF, check for pulley alignment using a straightedge. Any misalignment must be corrected by replacing defective parts or by realignment of accessory mountings. Serpentine belt

manufacturers tell us that modern belt composition does not show the usual signs of dryness and cracking as they age. The proper way to test serpentine belts is by using a wear gauge (see image).

4. Identify power steering pump noises, vibration, and fluid leakage.

If the PS fluid is low, a groaning noise in the power steering pump may be heard, or hesitation at the steering wheel may be felt. With the system up to the proper level of fluid, turning the steering wheel from "lock to lock" should be smooth and free of noise. Expect the pressure relief valve to make a hissing sound when the steering wheel reaches the end of its travel; do not hold the steering wheel in this position for more than a few seconds.

The steering wheel should rotate with equal pressure towards both the left- and right-hand direction. Use a spring scale on the steering wheel to be certain. You can also check power steering pump pressure when turning the steering wheel back and forth. Use a pressure gauge and "T" plumbed into the high-pressure power steering hose. Any imbalance of pressure between left and right turns could be caused by defective seals in the power steering components.

Inspect the entire power steering system for leaks. Start at the pump and reservoir, and then inspect the PS rack and high-pressure hoses. Be sure to include checking the PS fluid return line leading back to the reservoir for leaks, and for signs of power steering fluid on or around the PS rack bellows.

5. Remove and replace power steering pump; inspect pump mounting and attaching brackets; remove and replace power steering pump pulley; transfer related components.

Inspect power steering pump mountings with the engine running. Have an assistant turn the steering wheel about one- half turn in both directions. Watch for any unusual movement of the steering pump as the wheel is turned. Any pump movement in its brackets or bushings means the brackets need tightening or the bushings need to be replaced.

When replacing a power steering pump, loosen the hoses and catch the power steering fluid in a suitable pan or container. Once the pump has been removed, take off its pulley, mounting brackets, and associated hardware and transfer these items to the replacement pump before installation. Start the engine and check for leaks.

6. Inspect and replace power steering hoses, fittings, O-rings, coolers, and filters.

A thorough underhood and undercar inspection for leaks in power steering hoses and fittings should be performed whenever a vehicle is brought in for routine service. Power steering high-pressure hoses may have become old and hardened, or perhaps the "O" rings used in PS components have suffered from use or aging. In either case, looks for telltale leaks that indicate the need for service.

If used, check the undercar cooler for leaks caused by stones or road debris. If there is a PS filter, be sure to change it according to the respective vehicle maintenance schedules. It may be a separate in-line filter, or it may be located at the bottom of the PS fluid reservoir.

7. Inspect and replace rack and pinion steering gear bellows/boots.

Squish the PS bellows (boots) on either side to determine if power steering fluid has accumulated inside. Hard to squish stiff-type bellows will need to be slid back to check for rack seal leakage as evidenced by PS fluid buildup inside. Carefully inspect the bellows for dryness and for cracks, tears, or other defects. If loose, but otherwise serviceable, tighten the clamps to the manufacturer's specifications. If a boot needs replacing, slice it open to remove it, and at the same time, inspect the rack seals for leakage. If rack seal leakage is noted, the rack will need to be removed and replaced. To replace a bellows, the tie rod end must normally be disconnected and removed in order to slide a new bellows into place.

8. Flush, fill, and bleed power steering system.

If the power brake reservoir is low on fluid, find out why. Its level does not drop unless there is a leak. Likewise, if the fluid is discolored (brownish in color) or contaminated with moisture, rust, or dirt, it is time to drain and flush the system and replace the old PS fluid with fresh PS fluid. Even if it the fluid appears to be clean, check the maintenance schedule as well to see if it is time for such service.

Be sure to check the manufacturer's service procedures for the correct PS system drain and flush procedure. A general procedure involves placing the vehicle on jack stands, removing the PS return line, starting and idling the engine, and letting the PS fluid drain into a suitable pan. At the same time, add fluid periodically until the fluid coming out looks as fresh as the fluid being poured in. Stop the engine when this point is reached, and replace the drain line. Fill the reservoir with fresh fluid.

To bleed the system, start the engine and move the steering wheel from lock to lock repeatedly. Add more fluid to the reservoir as required until no "growling" noises are heard in the system and the steering wheel turns smoothly with no jerkiness. Once the fluid is hot, top off the reservoir to the full mark.

Steering Linkage

9. Inspect, adjust (where applicable), and replace pitman arm, center link (relay rod/drag link/intermediate rod), idler arm(s) and mountings.

On older RWD vehicles, traditional recirculating ball steering gears and parallelogram steering linkages were widely used. Recirculating ball steering gears are typically bolted to the vehicle frame and these bolts must be checked for tightness. If necessary, torque them to manufacturer's specifications.

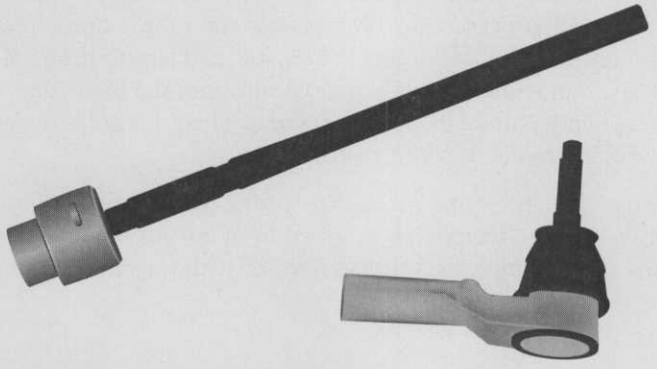
All links, rods, and rod ends used in parallelogram steering systems must be inspected for being bent or loose. Grasp each component and shake it to see if there is any play in the steering linkage. Likewise, with the front end on jack stands, start the engine. With the engine idling, have an associate move the steering wheel from lock to lock as you watch beneath the vehicle for any unusual movement or play in the connecting links and/or mountings.

10. Inspect, replace, and adjust tie rods, tie rod sleeves/adjusters, clamps, and tie rod ends (sockets/bushings).

Tie rod ends take a beating and need to be routinely inspected for wear. Collisions with rocks and road debris can damage low-hanging steering components, including the tie rod boots, adjustment sleeves, connecting links, and the tie rod ends themselves.

To check the tie rod ends with the front wheels off the ground, grasp each front tire at the 3 o'clock and 9 o'clock positions and try to rock the tire sideways. Any looseness could be due to play in the parallelogram steering linkage, but more likely it is due to the typically beaten and worn tie rod ends or steering knuckles. Some tie rod ends have wear indicators, or markings, that serve to indicate if the tie rod end is worn beyond its safe service life.

You can also check for steering system looseness from behind the wheel. With the front wheels straight ahead and the engine off, rock the steering wheel gently back and forth from straight ahead and take note of the steering wheel's free play; compare it to specifications. If there is excessive play, check all of the steering components for looseness, wear, or damage. If the tie rods are replaced, the toe adjustment is upset and a front-end alignment is required.



Tie rod ends take a beating and need to be periodically inspected and replaced.

11. Inspect and replace steering linkage damper(s).

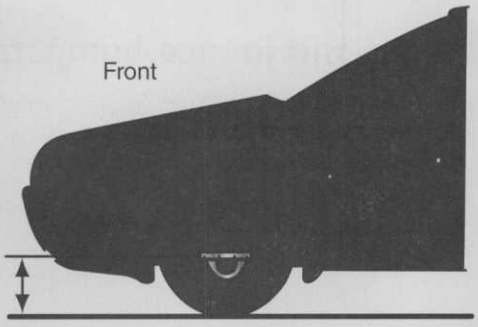
Along with the venerable air-cooled VW bug, some rear wheel drive luxury vehicles, trucks and SUV-type vehicles, use a steering damper to help reduce kickback to the steering wheel when rocks or potholes are encountered. Steering dampers act like horizontal steering linkage shock absorbers, and they are checked similarly to suspension struts/shocks for damage, wear, leakage, or looseness. In order to check steering dampers, drop one end of the damper and flex the rod in and out. The same resistance should be encountered when the rod is moved in either direction. If the damper rod does not offer enough resistance to endwise movement, replace the damper.

Front Suspension

12. Identify front suspension system noises, handling, ride height, and ride quality concerns; disable air suspension system.

There are a number of possible causes for suspension system noise complaints; for example, worn tie rod bushings may cause a rattling noise on road irregularities. Worn 4WD front leaf spring shackles and bushings may also cause a rattling noise on rough or uneven roads. Worn sway bar bushings may be the cause of a knocking sound when driving slowly over irregular roads or driveway surfaces. Dried-out sway bar bushings may squeak or emit a knocking sound. Upper strut bearings on MacPherson strut suspensions may knock when the vehicle is driven over uneven or unpaved surfaces.

Improper vehicle handling or improper ride height of the vehicle may be caused simply by incorrect loading of the vehicle (excessive or unbalanced loading). Vehicle handling concerns may also be due to incorrect wheel alignment settings, or because of worn tires or shocks/struts. Incorrect handling could also be caused by worn or damaged steering and suspension components themselves.



Curb riding height measurement, front suspension.

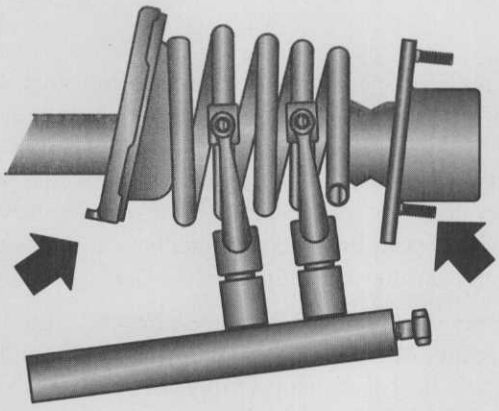
Check the service manual for proper ride height specifications. Check the vehicle with the tires properly inflated and the normally carried provisions on board. If the ride height is too low, suspect worn or collapsed springs or an excessive load on the vehicle.

> *Note:* Whenever a vehicle with air suspension is to be raised on a floor jack or lifted off the ground, be sure to disable the air suspension system by first locating and turning OFF the on-board air pump. Follow the vehicle manufacturer's instructions when disabling air suspension systems to avoid burning out the pump from overwork.

13. Inspect upper and lower control arms, bushings, and shafts.

Worn upper and lower control arm bushings affect the front end caster and camber angles (see Wheel Alignment Tasks D.41 and D.42) of the front suspension. If incorrect, these adjustments may cause vehicle pulling to one side or the other, along with excessive tire wear. Check the upper and lower control arms for any loose conditions. If the control arm

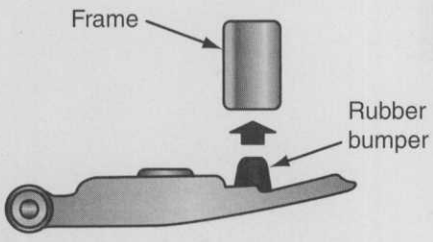
bushings are worn, erratic steering and/or noises may be heard by the vehicle driver when driving on uneven or irregular roads. Dry or worn bushings may squeak as the vehicle bounces up and down.



Aligning lowest bolt on upper strut mount with tab on lower spring seat.

14. Inspect and replace rebound and jounce bumpers.

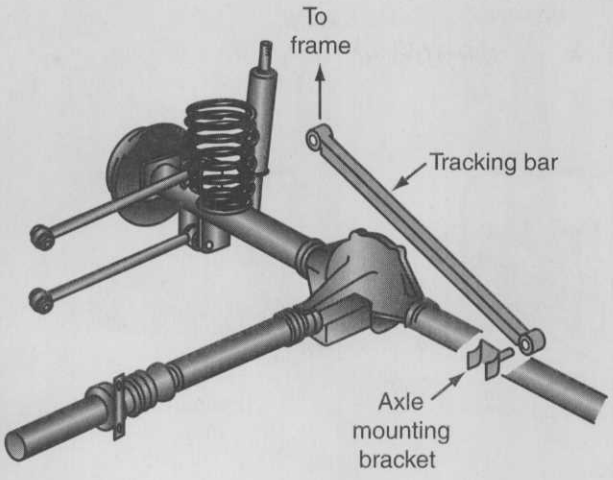
Rebound bumpers should be inspected for cracks, wear, or damage. Sagging springs and low ride height may be the cause of damaged bumpers. Also check for worn shocks or struts.



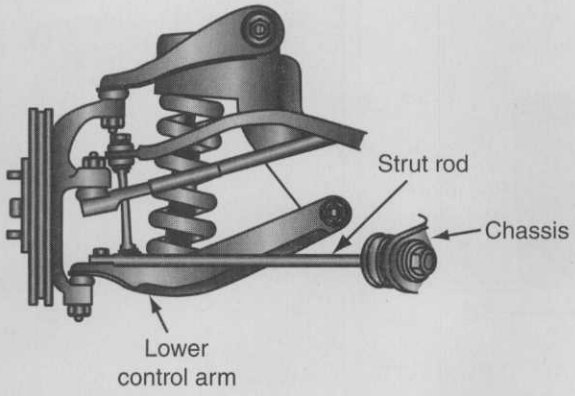
Rebound bumper.

15. Inspect track bar, strut rods/radius arms, and related mounts and bushings.

A track bar (aka tracking bar or panhard rod) helps to stabilize the chassis from lateral movement. Strut rods prevent fore-and-aft movement of the lower control arms. A bent or loose strut rod or tracking bar or loose, worn, or damaged bushings or mountings could contribute to handing (pulling) and ride problems. Check that these parts are firmly in place and free of defects.



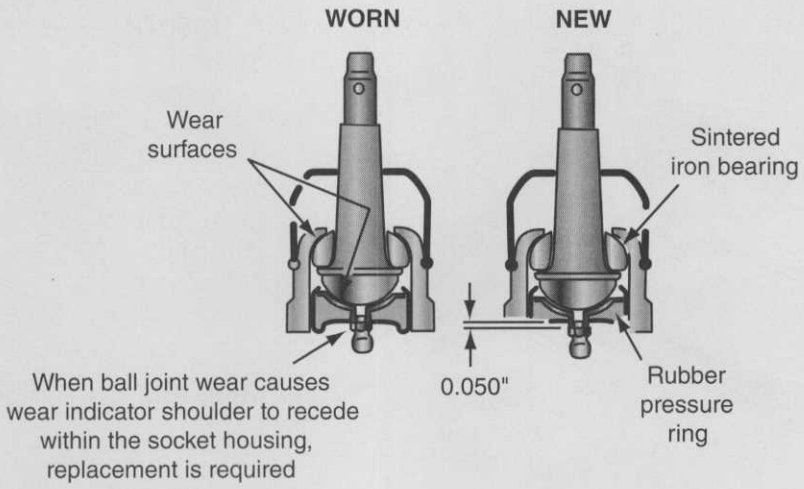
Tracking bar.



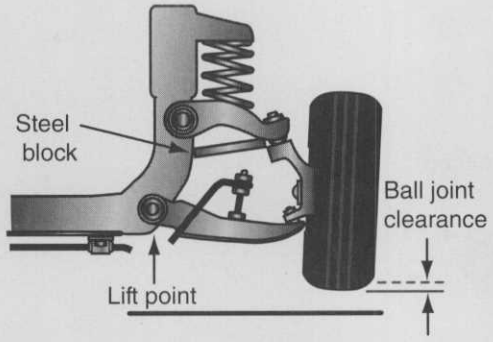
A strut rod.

16. Inspect upper and lower ball joints (with or without wear indicators).

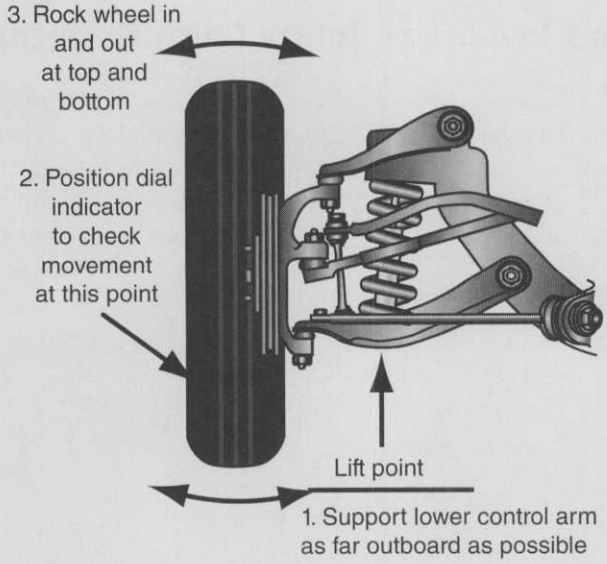
To check the ball joints, raise the vehicle front end about six inches off the ground to unload the tire. Slide a large tire iron under the tire and pry it up and down. As you do, feel for looseness in the ball joints. With the wheels raised, you can also grasp the top and bottom of the tire and push/pull on it while watching and feeling for looseness. When under the car's front end, wiggle the tire in and out while watching for play in the ball joints.



Ball joint wear indicator.



Live-axle, leaf spring rear suspension system.



Coil-spring rear suspension system with upper and lower control rods.

17. Inspect non-independent front axle assembly for damage and misalignment.

Non-independent front ends are designed for rough vehicle use, but they can be knocked out of alignment when off-roading or undergoing similar abuse. Some SUVs or pickups use a single I-beam; others may use a twin I-beam axle setup. Abnormal tire wear is an indication that the I-beam may be bent or otherwise out of alignment. Look for signs of rock impact (where rust has been scraped off) or where front-end repairs to the vehicle (fresh paint or new parts) has been performed, which could mean an alignment is required.

18. Inspect front steering knuckle/spindle assemblies and steering arms.

With the vehicle on a lift, check the steering knuckle and tie rods for looseness. Tie rods must be tight on their respective steering knuckles, and they must be secured with a cotter pin. On parallelogram-type steering, check for loose steering arms and inner and outer tie rod ends by firmly grasping the steering arms and wiggling them while watching for any looseness or feeling of play.

19. Inspect front suspension system coil springs and spring insulators (silencers).

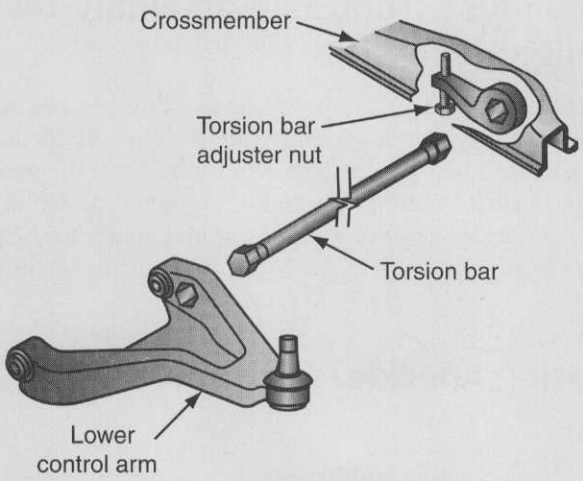
Coil springs may show signs of sagging on older vehicles. Check ride height to verify coil spring condition. Look for any collapsed coils or signs of abrasion from road debris. Bounce the vehicle while watching and listening for binding or noises. If used, make sure the spring silencers are intact and serviceable.

20. Inspect front suspension system leaf spring(s), leaf spring insulators (silencers), shackles, brackets, bushings, center pins/bolts, and mounts.

Front-end alignment and tire wear can be affected by weak or broken leaf springs. Such a condition can also reduce directional stability and cause a rough ride. Worn leaf spring shackles and bushings might also affect the vehicle's ride height. Inspect and check for looseness of these parts by firmly grasping them and shaking them. Replace any worn of damaged components or parts.

21. Inspect front suspension system torsion bars and mounts.

If equipped with them, check the vehicle's front torsion bars for straightness and for loose or broken mounts. If any damage is noted, replace the failed parts.

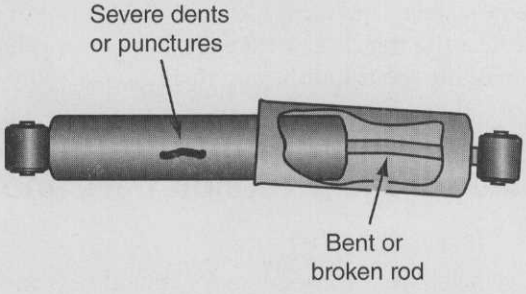


22. Inspect and replace front stabilizer bar (sway bar) bushings, brackets, and links.

A weak stabilizer (sway) bar or worn bushings will contribute to vehicle sway when going around turns or to vehicle stability when driving over rough roads. When driving slowly over irregular surfaces, listen for a knocking noise which may indicate worn sway bar bushings. In rare instances, the sway bar itself may become cracked or broken. All mountings should be visually inspected for wear or deterioration. Some vehicles have sway bar links. Check for bent or loose links and end connections.

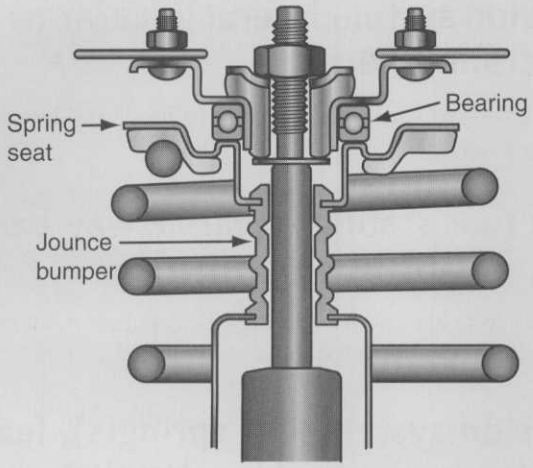
23. Inspect front strut cartridge or assembly.

Check the front struts for weakness by pushing down on each front corner of the vehicle. The vehicle should not continue to bounce or rock after letting go. Check for rust, damage, and for oil leakage from the struts. If any of these conditions exist, replace both front struts as a pair. After replacement, check the front-end alignment.



24. Inspect front strut bearing and mount.

Strut bearings are critical for smooth steering wheel operation, as well as for front-end alignment. Check that excessive effort is not required to turn the steering wheel. Check also for looseness at the upper end of the struts and listen for knocking noises when going over bumps.



25. Identify noise and service front wheel bearings/hub assemblies.

Wheel bearing noise is most evident when the bearings are side loaded during turns. When turning one direction and then the other at low speeds, listen for an unusual "growling" noise coming from the bearing area.

Many wheel bearings are now "sealed" (no service possible) and pressed into place in the front hubs. On older vehicles, (plus small trailers), ball and roller wheel bearings must be removed, cleaned, and repacked with bearing grease according to the maintenance schedule. If they are subjected to severe duty (e.g., exposed to heavy dust or sand; submerged into water at boat ramps, etc.), they will require more frequent service. Inspect these bearings for galling, pitting, or brinelling, and replace them as required along with a replacement grease seal.

Rear Suspension

26. Identify rear suspension system noises, handling, and ride height concerns; disable air suspension system.

Noises from the rear of the vehicle could range from squeaking to growling. Perform a test drive with the windows down, listening for gear noise from the RWD differential, an axle bearing growl from a non-independent/solid rear axle assembly, or noises from dry or damaged wheel bearings. Check for vehicle sway during turns, for a harsh ride, or for sagging or squeaky springs.

Check the service manual for instructions on how to disable the air suspension system before raising the vehicle off the floor (so the air springs' pump does not continue running and become damaged).

27. Inspect rear suspension system coil springs and spring insulators (silencers).

Check the coil springs for collapsed coils or excessive rust. Check the spring seats / insulators for damage which could allow noise to be transferred to the vehicle body. Check the vehicle's ride height.

28. Inspect rear suspension system lateral links/arms (track bars), and control (trailing) arms.

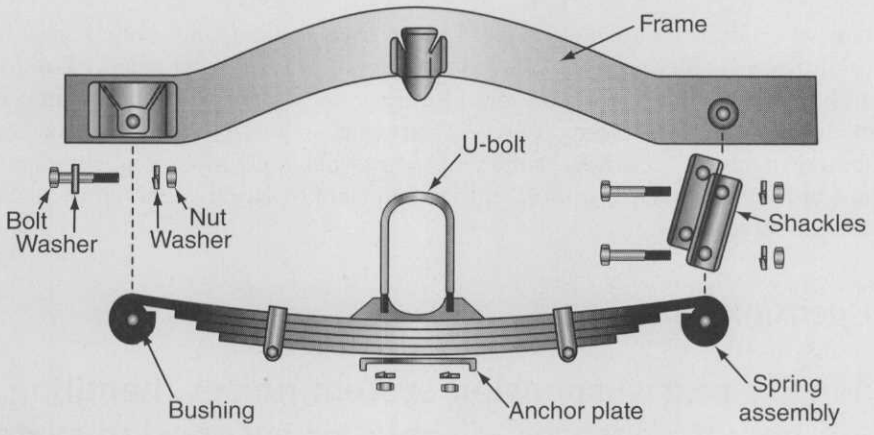
Check that the track bar (aka Panhard rod) and control arms (if used) and bushings are in good shape, which would help prevent unstable vehicle handling.

29. Inspect and replace rear stabilizer bars (sway bars), bushings, and links.

Check the condition of the (anti) sway bar and its bushings for dryness or cracking. If used, check the sway bar links for being bent or for loose ends.

30. Inspect rear suspension system leaf spring(s), leaf spring insulators (silencers), shackles, brackets, bushings, center pins/bolts, and mounts.

Leaf springs should be inspected for sagging, which would affect ride height, causing it to be less than specified. Visually inspect the individual leafs for cracks. The entire spring or individual leafs should be replaced if the springs are sagging or broken. Check for broken center bolts, worn shackles, or bushings.



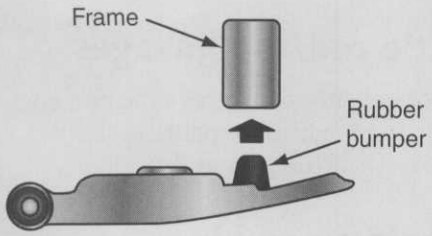
Check the plastic silencers between the spring leafs. If worn out, creaking and squawking noises are heard when the vehicle is driven over road irregularities at low speeds. When checking or replacing silencers, raise the vehicle with a floor jack and place jack stands under the frame rails so the rear suspension moves downward and the spring spreads apart. With vehicle weight removed from the springs, the leafs can be pried apart to remove and replace the silencers.

Worn spring shackle bushings, brackets, and mounts will likely allow unnecessary chassis lateral movement and produce rattling noises. With the vehicle weight on the springs, insert a pry bar between the rear outer end of the spring and the frame rail. Push down on the bar to check the rear shackle for movement. Shackle bushings, brackets, and mounts should be replaced if there is movement in the shackle.

A broken spring center bolt could allow the rear axle assembly to suddenly shift rearward on one side, which would alter the rear wheels' tracking (a frightening experience!). This severely affects handling, tire wear, and reduces directional stability.

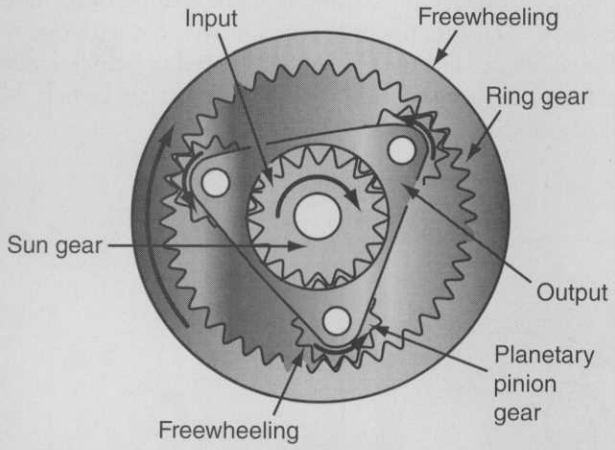
31. Inspect and replace rear rebound and jounce bumpers.

Rear rebound bumpers are normally bolted to the chassis. Check for cracks or flattened bumpers. Rebound bumper damage is usually caused by weak and sagging springs or by worn out shock absorbers or struts. Replace any worn or damaged bumpers as required.



32. Inspect rear strut cartridge or assembly, and upper mount assembly.

Check the rear struts for oil leakage or damage. If either is evident, replace both rear struts as a pair. Check the upper strut mountings for damage caused by heavy impact from rough roads and/or heavy vehicle loads.



Shock absorbers are another part that take a beating. Check them for rust, cracks, oil leakage and dry or deformed bushings.

33. Inspect non-independent rear axle assembly for damage and misalignment.

The rear axle can be shifted out of proper alignment due to hard impact with pot holes or road objects, or if the vehicle has been improperly lifted or towed. Axle housing misalignment will cause "dog tracking" of the vehicle. Check for damaged U-bolts and mountings of leaf springs and other components. Look for obvious signs of impact damage. Performing a 4-wheel alignment on the vehicle will reveal if the rear axle has shifted.

34. Inspect rear ball joints.

In independent suspension vehicles, check the rear ball joints for looseness or for a lack of lubrication. With the vehicle off the ground, grasp the tire and wiggle it from the 6 o'clock and 12 o'clock positions while observing the ball joints. Any ball joint play would indicate the need for replacement.

35. Inspect and replace rear tie rod/toe linkages.

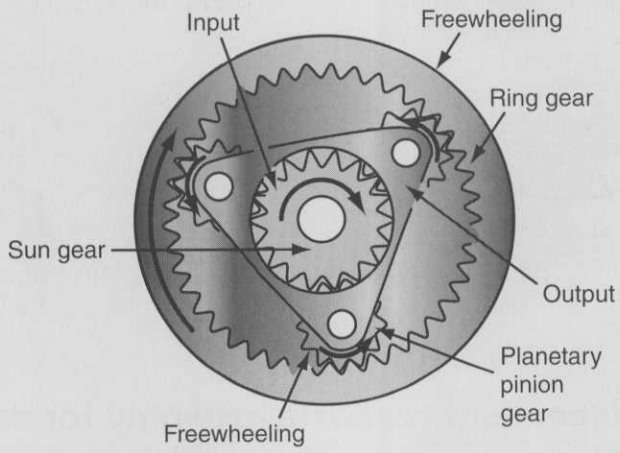
Check the rear tie rods for looseness or for indicated wear; check the grommets and mountings. Replace components as needed and tighten to specifications. When these parts are replaced, be sure to check the rear wheel toe settings.

36. Inspect rear knuckle/spindle assembly.

With the vehicle raised, watch for any knuckle play by grasping the tire and firmly wiggling it. With the rear wheel, brake drum, and wheel bearings removed, check the spindle for damage or being bent out of shape. Check for galling or rough spots that would prevent the bearing races from properly seating.

37. Inspect and replace shock absorbers, mounts, and bushings.

Check the shocks for damage, rusting, or oil leakage (a slight coating of oil mist is permissible). Bounce the car to see if the shocks dampen movement with one rebound. Check the upper and lower shock mountings for damage caused by vehicle overloading or from weak springs. Check that the rubber shock bushings are not dry or have been squeezed part way out of the mountings.



38. Identify noise and service rear wheel bearings/hub assemblies.

Drive the vehicle slowly and listen for a clicking noise, or in extreme cases, a grinding or growling sound, from the rear wheel bearings. If any noises are heard, disassemble serviceable rear wheel bearings and inspect for damage. If the bearings are sealed and pressed into a hub, press them out and replace them as a unit.

Wheel Alignment

39. Identify alignment-related symptoms such as vehicle wander, drift, and pull.

A recommended way to perform an alignment-related diagnosis is to take the vehicle on a test drive on a flat and level road and note any handling irregularities. Notice if the steering wheel is off-center as the vehicle travels straight ahead or if it has excessive play. Does the vehicle drift to one side of the road if the steering wheel is not held, and if so, towards which side? Does the vehicle shimmy, tend to wander within the lane when the steering wheel is pointed straight ahead, or experience "nibble" (slight steering wheel oscillations)? Does hitting irregularities in the road cause the vehicle to dart towards one side of the road or the other (bump steer)? Enter all such symptoms on the repair order and make certain the appropriate repairs are performed by a properly trained front-end specialist. Following any such repairs, a 4-wheel alignment will be called for.

40. Perform pre-alignment inspection; prepare vehicle for alignment, and perform initial wheel alignment measurements.

Make sure the tires are inflated properly. With the vehicle on the alignment rack, examine all four tires carefully for any clues indicating incorrect inflation, misalignment (see Task D.48). Make sure the tires match, i.e. are of the same type, correct size, and are mounted on the correct rims. If the tires are directional or asymmetrical, make sure they are properly positioned on the vehicle. Check to see if changes have been made to "plus size" the tires, or if rim offset has been changed from OEM specifications. Such changes will affect road feel, steering response, and handling.

41. Measure front and rear wheel camber; adjust as needed.

As viewed from the front of the vehicle, camber angle is the amount the wheel "leans" inward or outward from top to bottom. The camber angle may be positive (top leans outward), negative (top leans inward), or neutral (straight up and down). Camber affects the vehicle's ability to track properly and not dart from one side or the other. Check for tire shoulder wear, which is indicative of incorrect camber. Check the vehicle specifications against actual readings done on the alignment machine and correct the camber as required.

42. Measure caster; adjust as needed.

The caster angle is the amount of forward or rearward "lean" of a wheel's axis as viewed from the side of the wheel. If caster is "positive," the upper suspension pivot (ball joint or strut bearing) is rearward of the lower pivot. If caster is "negative," the upper pivot lies forward of the lower pivot. Most vehicles are designed with a slight amount of positive caster (think of a bicycle), but they may have zero or negative caster, as measured in degrees. Caster affects the ease of vehicle turning and the return of the vehicle's steering wheel to center. Thus, caster directly affects directional stability and tire wear. Front caster may not be adjustable on MacPherson strut front suspensions without fitting the OEM strut bearing with adjustable strut mounts. Set caster to specifications.

43. Measure front wheel toe; adjust as needed.

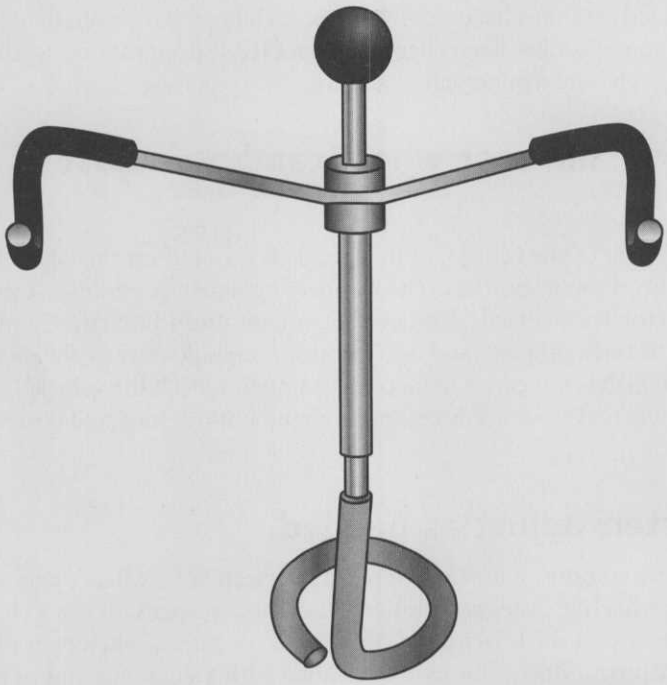
The vehicle's "toe-in" or "toe-out" is measured in either inch increments or in angles in degrees. Considering the two tires at the same axle (front or rear), the distance between the front of the tires is compared to the distance between the rear of the tires. With the steering wheel straight ahead, toe-in means the fronts of the two tires are closer to each other than the rear, and vice versa. If toe is incorrectly set, tire wear (feathering of the tread), turning response, and vehicle handling is affected. The wheels will toe-out when turning with the two front wheels assuming different degrees of toe. This helps to decrease the turning radius of the vehicle and makes turning easier with no tire "scrubbing."

The vehicle's toe angle also changes as the vehicle is propelled straight ahead. The OEM specifications may call for positive, negative, or neutral toe settings so that the wheels are effectively straight ahead when the vehicle is typically loaded and underway.

All vehicles have front-wheel toe adjustments; independent rear suspension vehicles provide for rear-wheel toe adjustments. Toe adjustments on the front wheels are made at the tie rod end adjustment sleeves. Adjust to specifications.

44. Center the steering wheel using mechanical methods.

In the interest of customer satisfaction, it is important to center and affix the steering wheel in the straight ahead position before starting a wheel alignment procedure. A special steering wheel holder (see image) is used to secure the steering wheel when certain alignment adjustments (ex: toe in) are being performed.



Use a tool like this to keep the steering wheel centered when performing a wheel alignment.

45. Measure rear wheel toe; adjust as needed.

No OEM rear toe adjustment is provided on vehicles with solid rear axles, but live (independent) rear suspension vehicles have provisions for rear -toe adjustments. Correct rear wheel toe is critical to vehicle stability when turning to help avoid "spinning out," especially under marginal road conditions.

46. Measure thrust angle.

The vehicle's thrust angle is defined as the actual direction in which the rear wheels point as compared to the geometric centerline of the vehicle. The positioning of the rear axle and rear wheel alignment affects the thrust angle and must be considered when performing a 4-wheel thrust line alignment. The optimum vehicle thrust angle is zero degrees.

47. Calibrate steering angle sensor.

After an alignment has been performed on a vehicle equipped with an electronic stability control (ESC) system, check that the steering angle sensor (which provides input to the ECU) is properly calibrated. Check that with the steering wheel pointed straight ahead there are no DTCs logged and no illuminated MILs indicating the steering angle sensor needs to be "zeroed." If necessary, connect a scan tool and perform a recalibration procedure according to the OEM procedures.

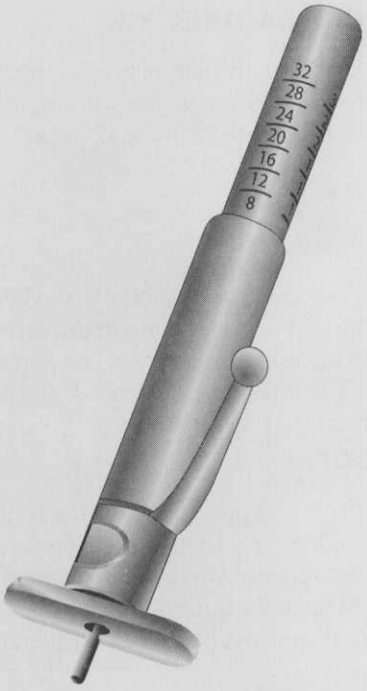
Wheel and Tires

48. Identify tire wear patterns.

Look for worn outer or inner shoulders that indicate incorrect camber. Check for signs of toe-related feathering (sawtoothed tread), scrubbing, tire-imbalance related cupping, or other abnormal tire wear patterns.

49. Inspect tire condition, tread depth, size, and application (load and speed ratings).

Check for any bulging of the sidewalls. Check for tears or splitting in the tread area. Make certain the tires are not worn down to the wear bar indicators, or use a tread-depth gauge to determine remaining tire life. Check with the tire manufacturer's resource manual to make certain the tires are the correct type, size, and speed rating for the vehicle, and that they are not overloaded. Some vehicles require a different tire size at the front versus the rear of the vehicle.



Use a tire tread-wear gauge like this to determine the remaining useful life of a tire.

When inflating tires on a vehicle, use the vehicle manufacturers tire pressure information found on the door or door jamb. The maximum inflation pressure indicated here is for general purposes only.

50. Check and adjust tire air pressure. Utilize vehicle tire placard and information.

Use an approved tire pressure gauge (digital readout or "stick" type) to make certain the tire pressure, as indicated on the driver's door or doorjamb sticker, is correct at all wheels. Some vehicles require a different inflation pressure at the front tires versus the rear tires of

the vehicle. Do not use the maximum inflation pressure spec on the tire itself for inflating the tires for a specific vehicle being serviced, as the max. pressure spec is likely too high.

51. Diagnose wheel/tire vibration, shimmy, and noise concerns; determine needed repairs.

Check tires for cupping or bulging, which may cause vehicle vibration or steering wheel pulsations and noise. Unusually loud tire noise at higher speeds could be caused by harmonics generated in the vehicle's suspension system. Check the OEM's TSBs for recommendations of a change of tire manufacturer and/or tire type and model for a quieter ride.

52. Rotate tires/wheels and torque fasteners/wheel locks.

Check that wheels, studs, mounting faces, and bolt hole chamfers are clean and free of dirt, rust, debris, or wear. Do not lubricate the studs or wheel nuts. Rotate the tires per the OEM maintenance schedule taking into account the type of tire (bias ply or radial) being installed and the type of vehicle drive (RWD and 4WD versus FWD). Make certain that directional and asymmetrical tires are mounted on the correct side of the vehicle. Inspect, install by hand, and lightly wrench tighten wheel mounting bolts or lug nuts. Torque them to factory specifications in an alternating sequence. After tightening locking type lug nuts or bolts, be sure to return the key to the vehicle owner.

53. Dismount and mount tire on wheel.

When dismounting tires from their rims, follow the tire changer machine manufacturer's instructions. To avoid damage to TPMS sensors, start separating the bead from the rim with the valve stem at the OEM-required position (i.e., some recommend breaking the bead at 6 o'clock, some at 9 o'clock, from the valve stem position). Do not remove the valve stem entirely; if it needs replacing, be sure to use the properly plated valve cap and stem.

When remounting the tire on the rim, follow the tire machine manufacturer's instructions along with OEM guidelines. Make certain the tire and the rim match regarding their size and bead taper angle. Replace the rubber tire valves used on conventional wheels.

54. Balance wheel and tire assembly.

Except for emergencies, avoid static tire balancing. According to tire manufacturers, the most desirable method of balancing a tire and wheel assembly is by using an off-the-car computerized tire balancing machine. Follow the tire balancing machine's manufacturer's instructions for accurate dynamic balancing.

55. Identify and test tire pressure monitoring systems (TPMS) (indirect and direct) for operation. Verify instrument panel lamps operation; conduct relearn procedure.

Various automobiles make use of different types of TPMS systems. Look up the system used for the vehicle in question in the vehicle service manual or the tire manufacturer's Tire Resource Manual. Check that the TPMS dash light goes out with the key ON and the tires are properly inflated. When rotating tires, a TPMS relearn/reset procedure should be performed to ensure proper location ID of a low tire pressure situation. A scan tool or special TPMS device may be needed to do this. TPMS Relearn is done with the ignition ON and in a particular tire location sequence (e.g., LF, RF, RR, LR). DO NOT forget to include the spare tire in this process.

56. Repair tire according to tire manufacturers' standards.

Tire repair should only be performed to the tread area of the tire, not to the sidewall. The puncture or injury should not be larger than ¼ inch (6 mm) in diameter. The tire should be removed from the rim in order for a proper tire inspection and repair to be performed. The one-piece tire plug and patch is the preferred (and fully legal) way to repair a hole in a tire. Follow instructions that are provided with the patch kit, making sure the repair area is properly cleaned, buffed, vulcanized, and ultimately sealed.

E. Brakes (11 questions)

1. Check for poor stopping, pulling, dragging, noises, high or low pedal, and hard or spongy pedal.

Before taking a vehicle with a braking system complaint for a test drive, make absolutely certain to read the repair order, looking for any indication of a brake system failure. When safe to do so, drive the vehicle slowly, away from other traffic, and apply the brakes lightly. Take careful note of the vehicle's brake system behavior.

Listen for noises such as the grinding of rivets against the brake drums or of disc brake backing plates grinding against the rotors. Listen for the squeal of a wear indicator against a rotor, especially with the brakes applied and during turns.

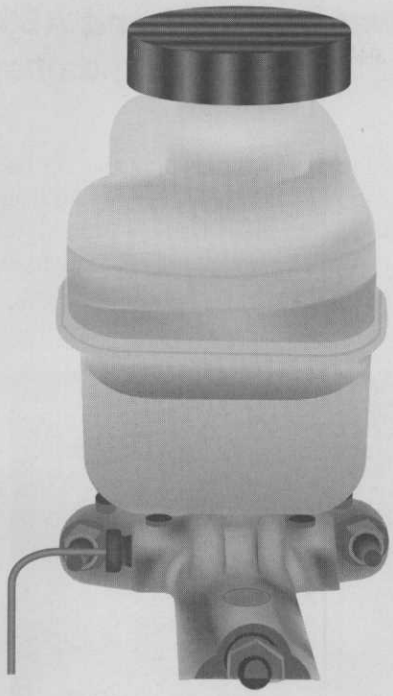
Check for pulling to one side or dragging that could indicate something is broken at one wheel or that a brake line is pinched of clogged. A pulsating pedal under moderate or severe braking may be caused by one or more warped rotors. Check if the power-assisted brakes are hard to apply, the vacuum booster may have failed or there is a vacuum line leak. There could also be a partial system failure or pinched or clogged brake lines.

Take note of the brake pedal height. If it is high (less than about a quarter inch), check the vehicle specs. The pushrod may be too long and it needs to be shortened. If the pedal is low (too much free play) it may be due to brake wear, damaged parts, a brake fluid leak, or a too short pushrod. If it goes to near the floor, the system may be leaking brake fluid from one circuit. If it goes completely to the floor (in a dual circuit brake system), there is likely a serious mechanical failure. It is unlikely that both circuits have failed. Take note if the pedal is soft or "spongy," which may indicate the need for bleeding or the need to replace the seals. Seal failure could be due to wear and tear or contamination by petroleum-based liquids.

Note if the pedal sinks slowly when lightly applying and holding the brakes while stopped; a seal in the master cylinder may be faulty, requiring the master cylinder to be rebuilt or replaced.

2. Check the master cylinder fluid level and condition; inspect for external fluid leakage.

One of the first things to check during a maintenance inspection is the brake fluid level and its condition in both sections of the master cylinder or reservoir. The fluid level will drop as brake pads wear, resulting in a lowering of the brake fluid in the reservoir. Visually inspect the entire brake system for leaks. The reservoir on most vehicles is of the see-through design so the cap or lid does not have to be removed for checking. Most brake fluid types are hygroscopic, which means they absorb water/humidity. Also, over time, brake fluid picks up metal and other foreign matter, so it may need to be replaced periodically.



Notice on top of this brake master cylinder the see-through reservoir which enables the brake fluid level to be checked without exposing the brake fluid to contaminants. Note also the brake warning light wiring and brake line connections which should be inspected.

Check the condition of the brake fluid by looking at it or by testing its condition. Most brake fluids appear clear; however, some may be amber or red colored. If the brake fluid is murky brown or contains impurities, flush the hydraulic braking system and replace the fluid. Test the fluid properties with a brake fluid test strip or by checking its electrical (galvanic reaction) properties using a digital voltmeter. Generally, there should be no more than 0.3 volts between the fluid itself and the metal master cylinder housing (electrical ground).

3. Inspect flexible brake hoses, brake lines, valves, and fittings for routing, leaks, dents, kinks, rust, cracks, or wear; inspect for loose fittings and supports; determine needed repairs.

Flexible brake lines should be checked for areas of brake fluid seepage as indicated by darker, moist areas. Vibration under the hood can stress even steel brake lines. Check for external leaks along the lines and around the brake line fittings. Tighten the fittings to specifications using a flare wrench. Do not over tighten a fitting in an attempt to stop a leak; rather, a new fitting, or the entire brake line (complete with new fittings) should be installed. Any brake line dents, kinks, rust, or cracking is not permitted and is cause for brake line replacement.

4. Verify operation of brake warning light and ABS warning light; inspect brake system wiring damage and routing.

Consult the vehicle owner's manual or service manual for the applicable on-board brake warning indicators, and with the ignition turned on, note if all the brake warning lights illuminate as they should during the self-test sequence. The brake warning light will be red and the ABS warning light will be yellow. A red light may indicate low fluid, a sticking sensor float in the brake fluid reservoir, or simply that the parking brake is set.

This image shows an IPC during a KOEO self-test sequence. Getting past all the confusion, note the top center red brake warning light and the yellow ABS light.

While under the hood, make certain the brake warning system wiring and its connections on the master cylinder are intact and damage free. Check that the brake warning circuit wiring is not near the hot exhaust manifold, the EGR plumbing, or other areas of concern.

5. Test parking brake indicator light, switch, and wiring.

While behind the wheel, apply the parking brake, making certain it activates the brake warning light or dedicated indicator lamp. Make certain its wiring is properly secured behind the dash or under the center console. If the brake light remains off when the parking brake is applied, check the fuse. Disconnect the wiring from the brake light switch and ground it; the light should come on. If it does, check the switch with a DVOM for continuity. If the light stays on all the time, also check the switch. Check its adjustment by cycling the parking brake several times to see if the light goes OFF. If it still remains on, disconnect all switches that activate it one at a time: park brake switch, low-fluid switch, pressure differential switch, and the ignition.

6. Bleed and/or flush hydraulic system.

Following the vehicle maintenance schedule, or as needed, perform a brake system flush and refill according to the manufactures recommended procedure. Brake system flushing may be done by using a special brake flush machine or by using a pressure bleeder, vacuum bleeding, or manual bleeding. Follow the instructions for the pressure bleeder, which will force fresh brake fluid into the brake system as you open and close each wheel cylinder or caliper bleed screw one at a time until the brake fluid comes out clean.

7. Select, handle, store, and install proper brake fluids.

There are various types of brake fluid, each designed for specific vehicles and their brake system needs. Be sure to use only the fluid the OEM recommends for a given vehicle. Many vehicles use DOT3 fluid, which is hygroscopic and generally clear in color. A few vehicles may require silicone-based fluid or another brake fluid. Brake fluid kept in a sealed container does not generally go bad, but once the container or can has been opened, the fluid can quickly absorb water from the ambient air. Hence, when brake fluid is stored, the containers should be kept tightly sealed. Brake fluid can ruin the paint of a vehicle, so avoid spills on the vehicle when adding to or refilling the brake system. Pour fresh brake fluid into the master cylinder reservoir using a clean plastic funnel, and only until the fill line is reached. Then, promptly close the master cylinder reservoir.

Drum Brakes

8. Remove, clean, inspect, and measure brake drums; follow manufacturers' recommendations in determining need to machine or replace.

Replacing brake shoes and hardware can be a dirty and difficult job until the service technician gains some experience. Brake drums may or may not include the wheel hub. Follow the manufacturer's instructions for how to remove them. When removing and cleaning brake drums, use personal protection equipment (PPE) and OSHA-approved devices and methods that capture the hazardous brake dust and minimize risk to personnel.

Once cleaned, check the drums for hard spots, hot spots, concave or bell mouth surfaces, or deep grooves or scoring. If cracked or damaged, discard the drum and replace it. Determine if the drums will require their friction surfaces to be cleaned up on a brake lathe. Use a brake drum micrometer to determine if the drum is warped or out of round, or if the maximum wear limit (discard dimension) has been reached or exceeded (or would be, once the drums are "turned"). Adhere to the drum manufacturer's wear limit specifications that are found stamped or cast on the drum.

9. Machine drums according to manufacturers' procedures and specifications.

Follow the brake lathe manufacturer's instructions when resurfacing brake drums. If it is not a single cut machine, a finish cut may be needed. Avoid removing too much material in one pass or cutting too fast, which creates a "threaded drum" and causes the brake shoes to follow the cut and make a "snapping noise" as the brakes are released.

10. Using proper safety procedures, remove, clean, and inspect brake shoes/linings, springs, pins, self-adjusters, levers, clips, brake backing (support) plates, and other related brake hardware; determine needed repairs.

Follow OSHA regulations and approved methods of brake dust control. Wear PPE (goggles, gloves, and paper mask) when servicing wheel brakes. After removing all drum brake hardware and shoes, determine if major components (self-adjuster linkage, adjuster screw assembly, and wheel cylinder) need replacing. The springs and hold-down parts are generally supplied in a kit and replaced when rebuilding/replacing drum brakes (shoes).

If reusing the springs, inspect for warped or bent coils, nicks, and a bent or twisted shank. Use soap and water and a wire brush to clean the backing plate and any attached parts. Catch all runoff in a pan and dispose of it properly.

11. Lubricate brake shoe support pads on backing (support) plate, self-adjuster mechanisms, and other brake hardware.

Once the backing plate is clean and dry, lubricate the pads where the shoes rest with specially formulated water-resistant grease. Avoid getting grease on the drum friction surface or the brake shoes' lining surfaces. After cleaning the threads on a wire wheel, use the same grease on the adjuster screw, and apply grease to other friction surfaces of the parking brake and self-adjuster mechanisms.

12. Inspect wheel cylinder(s) for leakage, operation, and mounting; remove and replace wheel cylinder(s).

Check the wheel cylinders by prying back gently on their boots. Check for signs of brake fluid inside, which would indicate the cups are leaking. Wheel cylinders may be rebuilt, but it's difficult to find rebuild kits. For this reason, the entire wheel cylinder is generally replaced. When replacing the wheel cylinder, use a flare nut wrench with caution when loosening and removing the brake line fitting from the wheel cylinder. It's easy to twist the fitting off the brake line! If this happens, a section of the brake line must be replaced. Clean all mounting surfaces and fasteners before installing a new wheel cylinder assembly.

13. Install brake shoes and related hardware.

With everything clean and inspected, have a replacement brake parts kit on hand, along with the proper lubricant. Have the tools needed (brake spring pliers, hold-down spring tool, brake spoon, and pre adjustment gauge) on hand. Having the right tools makes "hanging brakes" a lot easier.

Keep your hands grease free when installing the brake shoes themselves. Make certain not to reverse the placement of the primary and secondary shoes of duo-servo brakes systems. The brake shoe with the longer lining (the secondary shoe) goes towards the rear of the vehicle.

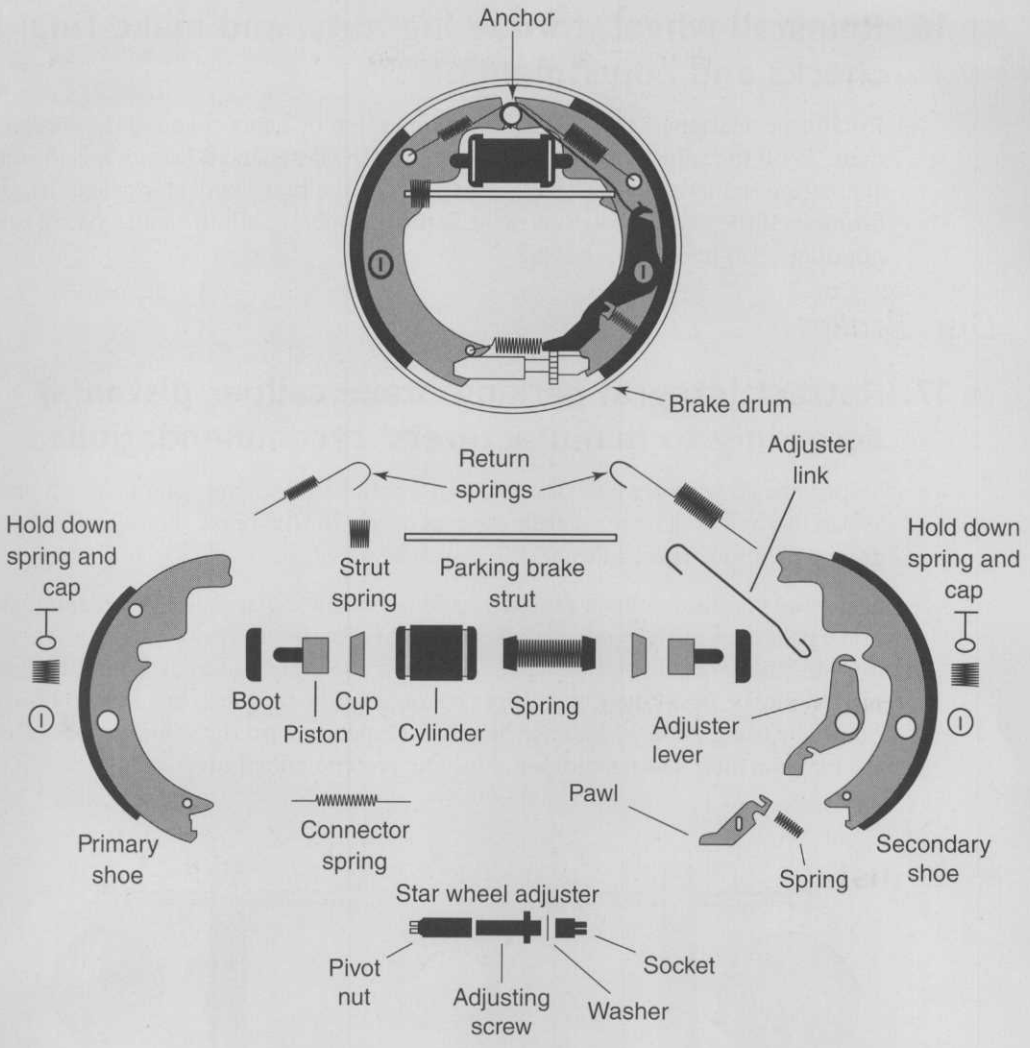
14. Adjust brake shoes and parking brake.

Once the shoes and all hardware are installed, preadjust the shoes with the star wheel adjuster according to the drum diameter as determined by using the brake shoe preadjustment/set gauge.

With everything installed, determine if the drum brakes need adjusting by pumping the brake pedal twice with the engine running. If the pedal rises (less free play) on the second pump, the drum brakes need to be adjusted.

Follow the manufacturer's instructions for making the final drum brake adjustment.

At the backing plate access hole, use a brake adjusting tool ("brake spoon") on the star wheel adjuster to tighten and center the shoes. On self-adjusting brakes, raise the adjuster lever with a small flat screwdriver while rotating the star wheel. Periodically bang on the drum to assist the shoes to seat. Tighten the adjuster star wheel until the drum (or tire and wheel assembly) can no longer be rotated. Then, back off the adjuster star wheel until the tire assembly (or drum) turns freely. Be sure to replace the rubber access hole plug.



15. Check parking brake system operation; inspect cables and components for wear, rust, and corrosion; clean or replace components as necessary; lubricate and adjust assembly.

Apply and release the parking brake, making sure the wheels rotate freely when released. Set the parking brake fully with the vehicle on a mild uphill and a mild downhill (both < 30 degrees) and determine if the brake holds the vehicle stationery. If the brake does not hold the vehicle, adjust the parking brake linkage according to the vehicle manufacturer's instructions. Some parking brakes are adjusted at the rear backing plate, others at the cable "equalizer" beneath the vehicle.

Inspect all linkage and cables for rust, kinks, or damage that could bind the parking brake cable in its conduit and prevent it from releasing. Check the parking brake mechanism and use an approved lubricant on it. Check the cable for broken strands, rust, or kinking. Replace it if it is damaged in any way.

Adjust the parking brakes only after the service brakes have been adjusted. Follow the OEM procedures, which generally involve adjusting the parking brake equalizer under the car. Following any adjustments, test the parking brake as described above.

16. Reinstall wheel, torque lug nuts, and make final brake checks and adjustments.

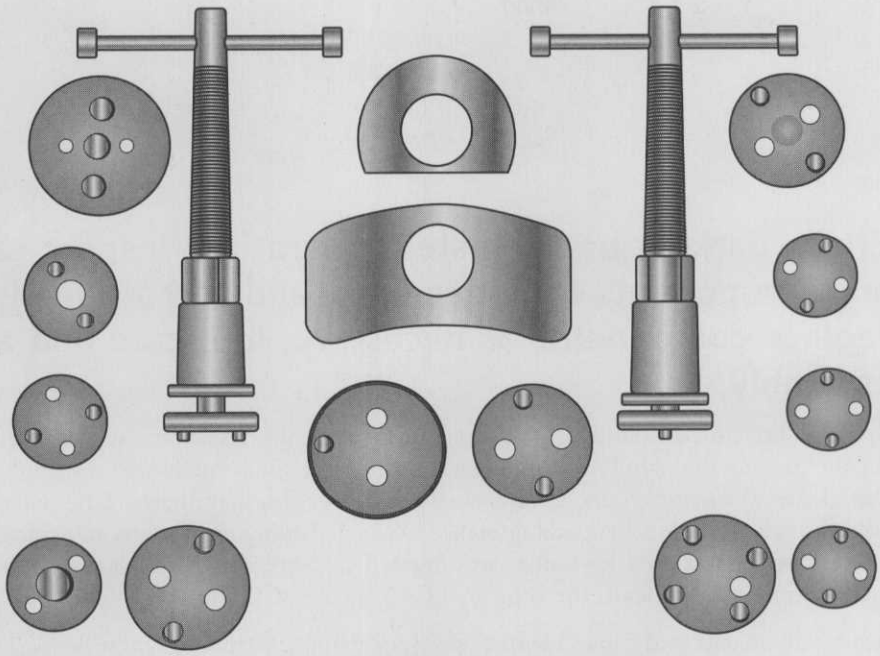
Install wheel fasteners by starting/threading them by hand, then lightly wrench-tighten them. With the vehicle on the ground, torque the fasteners to factory specifications in an alternating sequence (star or criss-cross). Check the brake pedal for proper height and firmness. If the pedal is too low, recheck the drum brake adjustment, making sure they do not drag. Also refer to Task D.52

Disc Brakes

17. Retract integral parking brake caliper piston(s) according to manufacturers' recommendations.

Some vehicles with 4-wheel disc brakes use a miniaturized version of a drum brake system as parking brakes. The rear rotors serve as drums for the brake shoes, and adjustments are done with a star wheel adjuster.

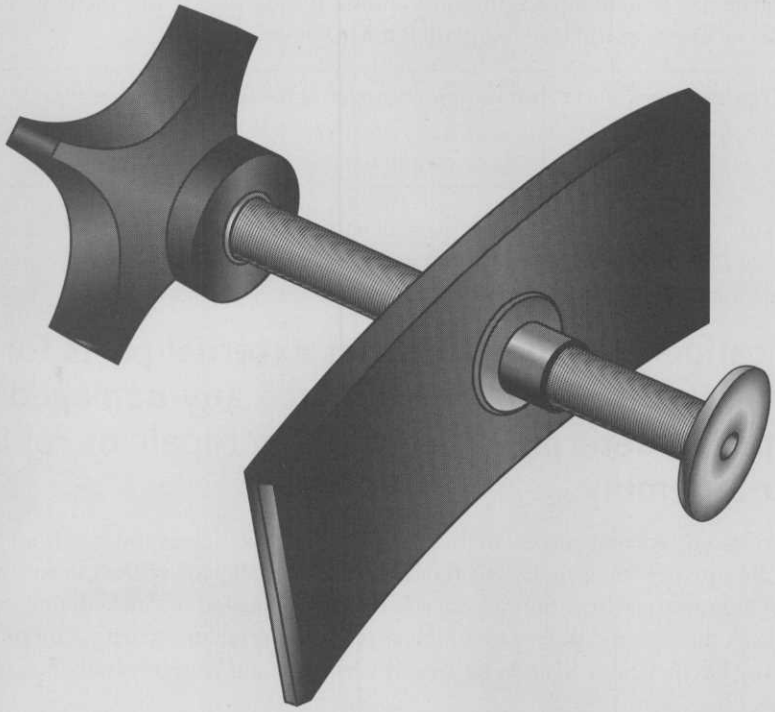
The more common caliper-actuated parking brake mechanically applies and locks the brake pads against the rotors. While a variety of methods are used, all are lever actuated from the inboard side of the caliper. To retract the brake pad away from the rotor so brake service may be performed, the caliper piston must be screwed back into its bore in the caliper by using a special spanner-like tool. Depending on the vehicle application, follow the manufacturer's instructions and use the recommended tools.



All sorts of piston retracting tool options are available to meet different vehicle needs.

18. Remove caliper assembly from mountings; inspect for leaks and damage to caliper housing.

The brake caliper must be loosened and most likely removed from its mountings in order to service the brake pads, the rotors, or the caliper itself. The specific procedure for the vehicle being serviced should be located in the OEM service instructions and followed carefully. Generally speaking, remove some brake fluid from the reservoir first. Some mechanics advocate opening the caliper bleed screw slightly to avoid pushing brake fluid back up the brake lines. Use a C-clamp or special tool to force the caliper piston(s) fully back into the bore.



Use a piston retracting tool like this, or a C-Clamp, to retract the piston into its bore so the caliper can be slid off the rotor and be removed.

Disconnect the brake hose, removing the mounting brackets and, on some calipers, sliding bolts, or pins. Pry the caliper loose from the rotor and lift it from the rotor assembly. Do not let it drop.

Inspect the caliper for leaks at the piston dust boot. If possible, peel back the boot and inspect for a leaking piston seal. If used, check the pin boots and bellows for tears. Check for physical damage from impact with road debris or from a collision.

19. Clean and inspect caliper mountings and slides/pins for wear and damage.

Sliding caliper slides and pins should be cleaned with brake parts cleaner and inspected for physical damage, nicks, burrs, or other irregularities. Check for rust, corrosion, pitting, or other problems. If any of these parts are damaged, pitted, corroded or rusted, replace them.

20. Remove, clean, and inspect pads and retaining hardware; determine needed repairs, adjustments, and replacements.

On some vehicles, the brake pads can be released and slid out of the calipers without loosening or removing the brake caliper. On most vehicles, the caliper will need to be dismounted from the spindle and hung up to avoid brake line damage. With the pistons retracted, the pads can then be removed from the caliper. On floating calipers, pins, keys, or other devices that are securing the pads need to be removed. Follow the OEM service procedures for removal of the pads from the caliper, and take note of their location. If the pads are to be reused, check the condition of the brake pad linings and the flanges. Generally, the pad should have a minimum lining thickness of 0.125 inch (1/8 inch or 3.175 mm) or more on the backing plate if it is to be reused.

> ***Note:*** *Repair one wheel at a time so you can refer to the other side of the vehicle if unsure about how things should go back together. Some replacement parts are typically supplied with new replacement brake pads; be sure to use them instead of the old ones.*

Clean all parts with brake cleaner and inspect all parts for rust or corrosion. Replace any that show wear or damage. If one pad has worn much more than the other on a given wheel, inspect the sliding caliper for freedom of movement and re-lubricate or replace parts as needed.

21. Clean caliper assembly; inspect external parts for wear, rust, scoring, and damage; replace any damaged or worn parts; determine the need to repair or replace caliper assembly.

Use brake cleaning solvent and a wire brush to remove road debris and rust from the caliper assembly. Be sure to wear goggles when doing so. Check all parts of the caliper for damage. Pay special attention to the mounting ears. If they are damaged or cracked, replace the caliper. Check the pins and slide areas for nicks or other irregularities that might prevent parts from moving freely. Check all areas for rust or corrosion and wire brush them as required.

22. Clean, inspect, and measure rotors with a dial indicator and a micrometer; determine the need to index, machine, or replace the rotor.

Clean the rotors with brake cleaning solvent and inspect them for hard spots (small blue areas) or for heat checking (small spider-like cracks) caused by the rotor's getting too hot. Check for deep grooves, scoring, cracks, or other damage. If deeply grooved (more than 0.015 inch), resurface the rotor on a brake lathe or replace it if doing so will reduce its thickness close to its discard thickness dimension (within ~.030 inch). Look for the discard thickness dimension cast or stamped on the rotor in thousandths of an inch or in millimeters. If minor rust is evident, remove it with emery cloth. If the rotor is heavily rusted, consider turning it on a brake lathe. If the rotor is cracked, scrap it. If so equipped, check the built-in wheel speed sensor carefully for damaged or missing teeth.

With the rotor secured by the wheel fasteners to its hub on the vehicle or secured in place on a brake lathe, check for rotor runout/warpage with a dial indicator. Check your measurement against the OEM specifications. Using OEM procedures, employ an inside micrometer to measure for uniform rotor thickness and parallelism. Compare your readings to OEM specifications. If the rotor is out of specifications in any way, consider turning it on a brake lathe or discarding it. If the rotor does not meet the discard thickness dimension, it needs to be scrapped.

23. Remove and replace rotors.

First, remove the brake caliper, as noted in Task E.18. Before removing the rotors, mark them with "Left" or "Right" for correct reinstallation. Use penetrating oil to help separate a rusted rotor from its mating hub. Sometimes tapping on it (not on the studs) will help free it. Once removed, separate two-piece rotors (rotor and hub).

When reinstalling a rotor, make certain all mating surfaces are free of rust and scale. Use a wire brush if necessary to ensure a clean surface. Any dirt or rust particles not removed will potentially create run out problems later on. Keep the rotor friction surface clean and free of grease and other lubricants. Remove the protective coating using soap and warm water, and wipe the surface dry with a lint free cloth.

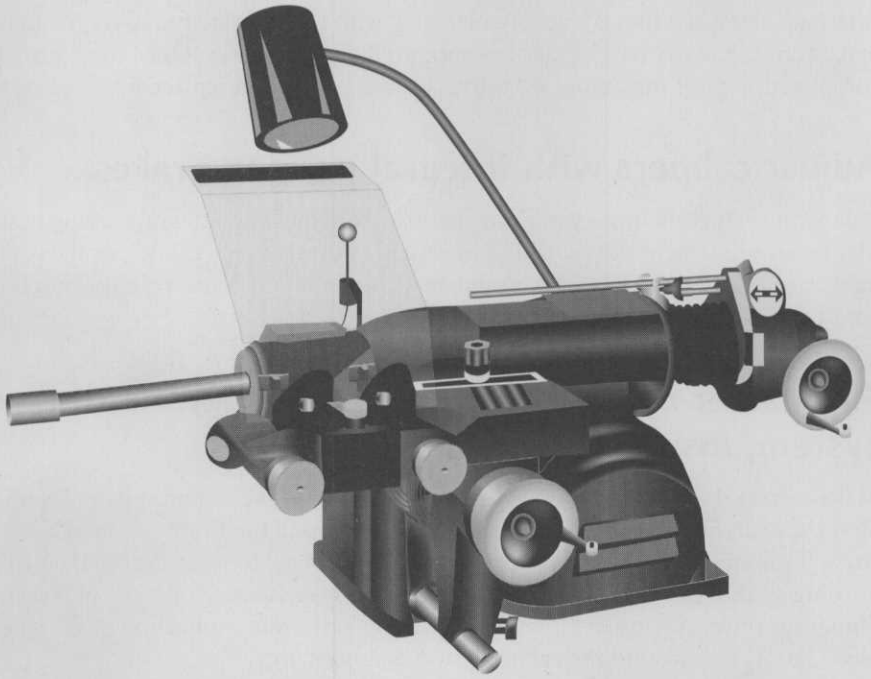
24. Machine rotors, using on-car or off-car method.

Machining the rotor on the car ensures near zero run out and generally saves the labor time of removing the rotor. Off-car brake lathe machining can also provide new life to an otherwise non-useable rotor.

Debate goes on whether or not the rotor should automatically be turned whenever it is removed from the vehicle. Turning rotors may be profitable, but removing any metal leaves the rotor thinner and less tolerant to recovering from the heat of braking (friction). On the other hand, leaving existing grooves and scoring on the rotor means the new pads will not seat as readily, and they will take longer to break in.

Whether on or off the car, follow the machine/brake lathe manufacturer's rotor machining instructions to the letter. When machining, remove as little metal as necessary to get a smooth rotor surface. Make certain the cutting bits are in perfect shape. Remove the same amount of metal from both sides of the rotor and from both same-axle rotors if possible. Avoid making too-deep cuts or spiraling the cut by advancing the bits too fast.

When finished, wash down the newly machined rotors with soap and water to remove any metal filings from the rotor surface. Towel them dry.



Use an on-car brake lathe or one like this if the rotors have been removed from the vehicle.

25. Install pads, calipers, and related attaching hardware; lubricate components; bleed system.

Unless there is a good amount of life left on used pads and they are in good shape, install new brake pads on the vehicle. Make sure all brake pad hardware, fasteners, and pins are clean and free of defects.

> *Note:* So-called organic brake pads are inexpensive; metallic pads last longer, but they may be noisy; and ceramic pads cost more, but they reportedly better handle the heat encountered during long downhill descents or when towing. Newer and better braking compounds are becoming common.

Follow the manufacturer's instructions when replacing the brake pads in the rotors. Make certain the correct pad is installed on the outboard side of the vehicle. Insert the pads into position and assemble all attaching hardware, including spring clips and anti-rattle devices. Make sure the pads are firmly seated, and bend the tabs (if used) as required for a firm fit. Some technicians use noise quieting paste on the backing plates of the brake pads; if doing so, apply the paste sparingly and only where the backing plate touches other parts. Lightly grease the slides, if used, with approved grease or anti-seize compound so the pads can move inward as they wear.

Slide the caliper into position on its mounting and over the rotor. Install a mounting bolt and swing the caliper fully into position on the rotor. Install the other mounting bolt and torque both of them to specifications.

Bleed the brakes using either the pressure bleeding or the vacuum method. When pressure bleeding, be sure to hold open the metering valve or use a special tool to hold open the combination metering/proportioning valve. Bleed the brake system according to OEM procedures, which vary widely depending on the make, model, and year of the vehicle. Generally, the wheel farthest from the master cylinder is to be bled first, but not always.

Alternatively, when brake bleeding manually with an associate pumping the brake pedal, make certain the master cylinder has enough fluid at all times. Once the bleeding is completed, top off the master cylinder, clean its cover, and replace it.

26. Adjust calipers with integral parking brakes.

Follow the vehicle manufacturer's instructions for adjusting integral parking brakes. There may be an adjustment nut or cable adjustment at or near each caliper, or the parking brake may be self-adjusting (Ford). For calipers with integrated drum-type parking brakes, adjust the star wheel.

27. Fill master cylinder with recommended fluid; reset system; inspect caliper for leaks.

Make certain the brake fluid being used is fresh and of the required type. Using a clean plastic funnel, fill the reservoir to the full line and install the freshly cleaned cover. Wipe up any spills immediately. Use a factory approved scan tool to reset the electronic brake warning system once any faults have been properly repaired. Apply the brakes firmly numerous times and inspect for any leaks at the brake line connection to the caliper, at the bleed screw, and around the caliper piston and boot area.

28. Reinstall wheel, torque lug nuts, and make final brake checks and adjustments.

Install wheel fasteners by starting/threading them by hand, then lightly wrench tighten them. With the vehicle on the ground, torque the fasteners to factory specifications in an alternating sequence (star or criss-cross). Doing otherwise could cause rotor warpage and subsequent pedal pulsation.

Check the brake pedal for proper height and firmness. If the pedal is too low, pump the brakes a few times to seat the pads on the rotors and recheck the brake fluid level in the reservoir.

29. Road test vehicle and burnish/break-in pads according to manufacturers' recommendations.

Take the vehicle for a test drive, making sure all previously reported symptoms have been taken care of. Breaking- in (aka bedding-in or burnishing) the new brakes is an important step not to be overlooked. Burnishing transfers pad material evenly to the rotors and cooks off pad residue, resulting in long and quiet brake life. It also helps eliminate brake squeal.

Perform the burnishing procedure according to the brake material provider's instructions. Some call for repeated light stops; others call for repeated moderate-to-heavy brake applications with specified wait times in between. Up to 30 repeated stops from a specified speed may be called for to complete the process. Recheck the wheel fastener torque when finished with the test drive/break-in procedure.

Power Assist Units

30. Test brake pedal free travel with and without engine running to check power booster operation.

To perform the power booster performance test on a vacuum-assisted brake system, pump the brakes numerous times with the engine OFF to remove any residual vacuum from the power booster. Make note of the pedal position. With your foot still on the brake pedal, start the engine and note if the pedal sinks. If the brake booster is working properly, you should feel the pedal sink an inch or more. If the pedal does not change its position, the booster is not working properly and you will need to check the vacuum supply to the booster.

31. Check vacuum supply (manifold or auxiliary pump) to vacuum-type power booster.

Remove the vacuum line from the brake booster and attach a vacuum gauge to the line coming from the intake manifold. Start the engine and read the vacuum gauge. The gauge reading should match the intake manifold vacuum measured elsewhere; that is, greater than 16 inches of vacuum. If not, check for a leaking or pinched vacuum line to the brake booster, or for a clogged or stuck-closed in-line vacuum check valve.

32. Inspect the vacuum-type power booster unit for operation, and vacuum leaks; inspect the check valve for proper operation.

See if the power brake booster vacuum line is firmly attached to the brake booster. If an in-line check valve is used, make certain you can pull a vacuum with a hand vacuum pump in one direction only. If it is stuck open or closed in both directions, replace it. Alternatively, idle the engine with your foot on the brake pedal, then shut off the engine, keeping your foot on the brake. Keep your foot on the brake pedal for up to 10 minutes. The pedal should not rise. If it does, it indicates a vacuum leak.

Check the booster itself for rust or holes. Run the engine and then turn it off. Pull the vacuum line off the booster and listen for air, which should rush into the brake booster. With the engine idling, applying the brakes should not affect engine idle speed or smoothness. If the engine idling becomes rough or the engine stalls, check for a failed brake booster.

33. Identify operation of electric-hydraulic assist system; check system for leaks and operation.

On some import vehicles, an electro-hydraulic braking system is used. This system uses a high-pressure reservoir which supplies the required braking pressure quickly and precisely to the service wheel brakes even without the driver's involvement. Electro-hydraulic braking systems offer improved active safety especially when braking in a corner or on a slippery surface.

The so-called Sensotronic Brake Control (SBC) electro-hydraulic brake system was developed by Daimler and Bosch. With electro-hydraulic braking, the driver doesn't directly activate the brakes. Rather, the master cylinder is activated by an electric motor or pump that is regulated by an electronic control unit. When the driver hits the brakes of an electro-hydraulic system, the control unit processes information from a number of sensors to decide how much braking force each wheel actually needs. The system then applies the necessary amount of hydraulic pressure to each brake caliper.

The system also includes functions to reduce the driver's workload, including Traffic Jam Assist (which brakes the vehicle automatically in stop-and-go traffic once the driver takes his or her foot off the accelerator) and a Soft-Stop function (which allows particularly soft and smooth stopping in city traffic).

Electro-hydraulic brake systems typically operate under much higher pressures than traditional systems. Where hydraulic brakes normally operate at around 800 PSI, the Sensotronic system operates at between 2,000 and 2,300 PSI.

34. Identify operation of hydro-boost assist system; check system for leaks and operation.

Check the fluid level and add fluid if needed. If the fluid is low, check for leaks. To test the hydro-boost system, with the engine OFF, pump the brake pedal 10 or more times to remove residual hydraulic pressure from the system's accumulator. Push firmly on the brake pedal and start the engine. The brake pedal should sink at first, then it should then push back against your foot. If it fails to do so, the system is not providing hydraulic boost.

To check the hydraulic accumulator, start the engine and turn the steering wheel against its lock. Hold it there for about 5 seconds, then release it. Shut off the engine, and wait for 30 minutes or more. Press on the brake pedal 2 or 3 times to check for power assist to the brakes (easy brake application). If power assist is not available for at least 2-3 applications, the accumulator is not holding pressure. Check for leaks along all of the hydraulic lines to/from the accumulator, as well as their fittings.

F. Electrical (8 questions)

1. Disarm/re-enable air bag; verify lamp operation.

Service to the air bag system requires disarming the air bag deployment circuits. Otherwise, accidental air bag deployment could occur, causing serious personal injury. Check the OEM service manual and follow its procedures to the letter before performing any work on the Supplemental Restraint Systems (SRS) to avoid accidental deployment of the system. Technicians are too often injured by accidental air bag deployment.

In general, disabling the front and side/side curtain air bags requires turning off the ignition, removing the SRS fuse(s), disconnecting various connectors (yellow colored) behind the dash and under the seats, and waiting the required time until the system's module powers down. See also Task D.1.

To re-enable (rearm) the air bag system, follow the OEM instructions. Reconnect any disconnected connectors, and replace the SRS fuse(s). With everything reconnected, turn on the ignition and make certain the yellow SRS light on the IPC self-tests—then goes out. If it does not, use the appropriate scan tool to pull any SRS trouble codes which exist and make note of them for follow-up service by a qualified technician.

2. Check voltages, grounds, and voltage drops in electrical circuits; interpret readings.

Think of a voltmeter as a balance-type scale, comparing electrical pressure from two places.

Voltage drop is the difference in electrical pressure (think again of the scale) between two points within an electrical circuit. To check a system or circuit for available voltage (electrical pressure, or EMF) dynamic resistance, connect the DVOM's leads across the load or cable to be tested, power up the circuit, and note the reading. For example, to test for resistance in a starter motor cable, connect the positive lead to the positive battery post and connect the DVOM negative lead to the starter solenoid's B+ terminal. While cranking the engine, note the voltage drop (lost electrical pressure) on the meter.

Check your readings taken against the OEM specifications.

> ***Note:*** *In accord with ohm's law, given a fixed amount of resistance, the greater the amount of amperage that is flowing in the circuit, the greater the voltage drop will be. This is why taking dynamic voltage drop readings is a superior method for finding unwanted resistance than using an ohmmeter to find static resistance.*

3. Check current flow in electrical circuits and components; interpret readings.

To measure amperage, the circuit must be live (current/amps flowing). Connect the appropriate inductive amps clamp (high or low amperage) around the cable or wire to be monitored for current flow. Be sure to observe the polarity markings on the clamp; if placed backwards on the wire or cable, the polarity read on your meter will be backwards. Power up the circuit and take your reading, scaling down as required. Compare your readings to specs.

If a current clamp is not available, you will need to "break into" the circuit to read amperage flow; current/amperage is always measured in series when measured from within the circuit. Be sure to choose the correct "DC Amps" meter lead cavities on your DVOM.

A DVOM will typically only read up to 10 amps (or less, check your meter), so make certain your meter is appropriate for what you are trying to measure; for example, you would NEVER attempt to read starter current amps (as high as 200 amps or more) using a meter wired in series.

Insert the DVOM leads at the place you broke the connection—at a connector or component—observe the correct polarity. The positive lead should be on the source-of-current side of the circuit; that is, closer to the battery.

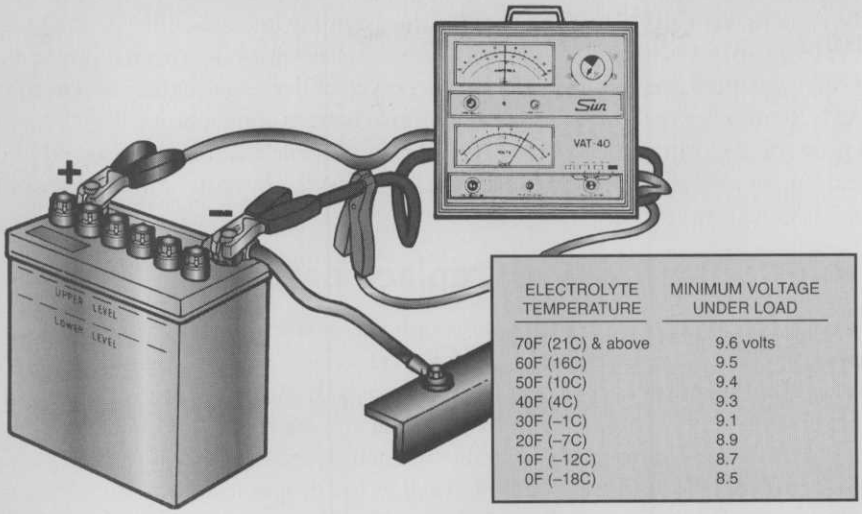
4. Check continuity and resistances in electrical circuits and components; interpret readings.

Use the Ohms scale of the DVOM for taking resistance measurements. Make certain the circuit has no power in it, because the ohmmeter supplies its own power from its internal battery. A live powered-up circuit will distort the meter's resistance reading, or even destroy the meter! You will likely have to isolate the load or remove it entirely from the circuit to get an accurate resistance reading. Resistance readings are always taken in parallel across the load (resistance) being measured.

5. Perform battery tests (load and capacitance); determine needed service.

> ***Note:*** *A two-minute period should be maintained between any load testing cycles to avoid damage to the battery.*

The battery load test is an effective and dynamic way to determine the capability of a battery. The test demands that the battery voltage deliver a specified amount of current (in amps) over a given amount of time without falling below a specified voltage potential. Thus, the load test determines if a battery can deliver when the going gets tough. It is done by placing a heavy load across the battery terminals. The load itself could be an actual starter motor cranking the engine, the vehicle's headlights, or an external load such as a carbon pile built into a volt-amp tester (VAT). In much earlier days, a simple load tester consisted of nothing more than a heavy duty "heater grid" with an analog voltmeter. The heavy resistive load was placed across each individual battery cell to essentially "short it out" and test its ability to sustain its voltage.



ELECTROLYTE TEMPERATURE	MINIMUM VOLTAGE UNDER LOAD
70F (21C) & above	9.6 volts
60F (16C)	9.5
50F (10C)	9.4
40F (4C)	9.3
30F (–1C)	9.1
20F (–7C)	8.9
10F (–12C)	8.7
0F (–18C)	8.5

It is important to start a load test with a fully charged battery. Typically, a load equaling one half of the battery's cold-cranking amperage CCA rating is placed on the battery for 15 seconds. The battery should still be above 9.6 volts at the conclusion of the test. If not, recharge and retest the battery. If it fails again, recycle the old battery and replace it.

Modern electronics has made battery testing faster, easier (and arguably), as reliable as load testing with the use of the capacitive-conductive battery tester. After entering pertinent battery data into the tester, the tester measures the battery's plate conductance (which represents the battery's internal condition), and issues a report of Pass, Retest, or Fail. Unlike with a load test, the capacitive-conductive tester can even check the battery plates' condition when the battery is low on charge. Capacitive-conductive testers are said to be able to tell the useful life remaining in the battery. Be sure to read and follow the tester manufacturer's instructions to ensure a reliable battery test.

> ***Note:*** *When testing AGM batteries, take note of any special requirements when entering the battery's CCA rating.*

6. Maintain or restore electronic memory functions.

If battery service is required, removal of the battery connections will probably erase any keep alive memory (KAM) data stored in the various on-board electronic modules. The engine and transmission may perform erratically when first started after battery power has been lost and restored, these must undergo a relearning process as the vehicle is once again driven. Likewise, with a loss of KAM, DTCs stored in the PCM are erased and the OBD-II monitors must rerun before a state-mandated emissions test can be performed.

Once KAM is lost, it cannot be retrieved. All lost settings must be reestablished, either through normal vehicle operation or by manually resetting (ex: radio presets), and the vehicle owner is inconvenienced at best. Some on-board devices with theft-deterrent features will need to be reactivated using a special code. Refer to the vehicle owner's manual or service manual for specific instructions on how to perform a reset procedure and how to obtain the reset code(s) needed.

What all this means is that it is easier to avoid erasing KAM in the first place. The secret is to provide the vehicle with constant auxiliary 12-volt power before disconnecting the

service battery. Auxiliary power can be provided via the data link connector (DLC) on 1996 and newer OBD-II vehicles, or via the assembly line data link (ALDL) used on pre-1996 OBD-I vehicles. Alternatively, on vehicles with B+ powered power outlets, a 12-VDC adaptor can be plugged into the power outlet/cigar lighter socket to maintain KAM. Remember that in so doing, the positive battery connection will be live with power, so keep the B+ connector well away from ground while cleaning it. Also, avoid opening the doors or activating the key fob that will turn on the interior lights and possibly overtax the 12-VDC power supply.

7. Inspect, clean, fill, or replace battery.

Start any battery inspection with a thorough examination of the battery case, its hold-downs, and the battery terminals. Look for cracks or leakage in the case. Check for damaged, dirty, or corroded top or side terminals. If the connections are dirty, wire brush them and clean off corrosion with baking soda and water. If the connections are clean, tighten the cable clamps using a suitable wrench. If the battery has removable caps, check the electrolyte level. If it is low, fill each cell to the proper level with distilled water. Be careful to not let impurities fall into the battery cells.

When replacing a battery, be sure to follow standard safety procedures. Remove the negative cable connection from the battery first (on a negative-ground vehicle) to avoid a short circuit caused by the wrench's touching against a metal ground. Batteries are rated by group number or their physical size, + and − post placement, and ampere/hour capacity. Make certain the battery being installed is the correct size and rating intended for the vehicle.

8. Perform slow/fast battery charge in accordance with manufacturers' recommendations.

If fully or heavily discharged, 12-volt vehicle batteries are best brought back up to a full charge by using an external battery charger. Do not rely on the vehicle's charging system to do so; the strain on the vehicle's alternator to bring a dead battery up to full charge could weaken and, sooner or later, cause the diodes in the alternator to fail.

Different battery types require different charging algorithms. Normal flooded lead-acid batteries can be slow charged, or fast charged within limits to bring them up to full service voltage (12.6 volts). A slow overnight charge is always best and easiest on a battery. If rapid charging must be done, be sure to use a voltage and amperage regulated charger, and set to the proper charge feature for the respective battery. Valve Regulated Lead-Acid (VRLA) may be of the gel type or Absorbent Glass Mat (AGM) type battery. These require a different charging algorithm (charging cycle), so check with the vehicle manufacturer or the battery maker for instructions on the safest, most efficient, and reliable charging method for these types of batteries.

9. Inspect, clean, and repair or replace battery cables, connectors, clamps, and hold-downs.

Automotive service battery connections should be periodically removed and cleaned of any buildup of residue or corrosion. Use a special battery cleaning wire brush on battery posts, side connections, and cable ends. Use baking soda and water to neutralize and wash away remaining caustic residue (green and white contamination). Follow standard safety and KAM retention practices (see Task F.7) when removing and installing the battery connections.

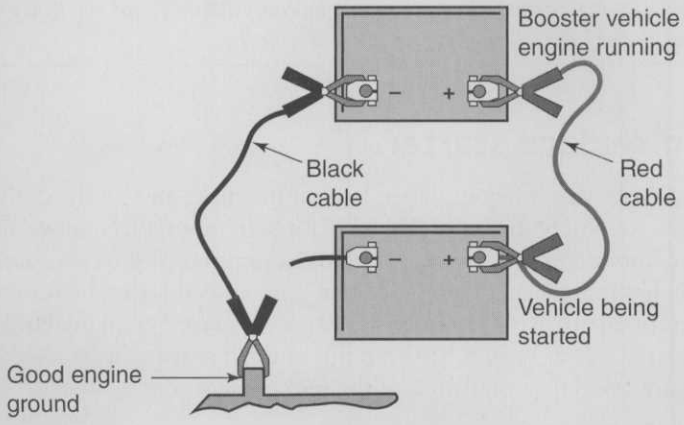
Inspect the battery cable ends for deterioration from corrosion or rust damage, and inspect the clamps or bolts for damage from abuse or over-tightening. Inspect the cables upstream from the cable ends for hidden corrosion under the insulation. Cut off and replace (by soldering with a torch) defective cable ends, following the supplier's instructions carefully. Only in emergency situations should bolt-on replacement cable ends be used; they are prone to short-term failure.

A 12-volt flooded lead-acid battery's life is shortened if the battery is free to bounce around under the hood (AGM and spiral cell batteries can take more of a beating). Still, be sure to check the battery hold-down devices for rust and corrosion. Wire brush and paint them as necessary or replace them altogether. Check that the elongated hold-down bolts grip as they should, and that they are not corroded or stripped. Replace them if needed. It is a good idea to clean the battery tray as long as the hold-downs are being serviced.

10. Jumpstart a vehicle with a booster battery or auxiliary power supply.

If a vehicle battery has been run down or seriously discharged from a parasitic load such as leaving the lights on, the vehicle will either require a fully charged replacement battery or a jump-start. Jump-starting can be done from an auxiliary power supply that provides a safe means of boosting a low or dead battery. A portable power supply comes complete with clamp-on battery cables, an ON/OFF switch, and reverse polarity protection. An alternative is to use standard jumper cables from a host vehicle with a good battery; it is not a good practice to rely on a battery charger for jump-starting.

Always connect the negative cable last to a good ground under the hood of the vehicle with the dead battery. Avoid connecting the cable near the battery, which may have vented explosive hydrogen gas when being discharged. Turn on the switch of the power supply and let the power supply transfer power to the dead battery for a couple of minutes. If using a host vehicle, run the engine at a fast idle for several minutes to partially restore a charge to the dead battery. Then, crank and start the dead battery vehicle. Shut off the power supply, first remove the negative (ground) cable previously clamped to ground, and then move it away from the dead battery. When removing the cable, do not temporarily clamp one cable to the other. The jaws of one clamp can bite through the insulation of the other cable, resulting in a massive short and undesirable results.



11. Perform starter current draw test; interpret readings.

> *Note: A two-minute period should be maintained between starter draw testing cycles to avoid damage to the battery.*

Starter current draw can be measured using a high-amp clamp on the negative battery cable or an inductive-type amp meter placed on the cable. Install the clamp so its arrow points away from the battery negative terminal. Use a remote starter switch or disable the vehicle's fuel supply by pulling the fuel pump relay. With the battery fully charged, crank the engine and read the amperage on your meter. Check your reading against the OEM specifications. In general, a V-8 gasoline engine starter will draw >200 amps, a V-6 will draw around 160 amps, and a 4-cylinder engine will draw around 120 amps. A diesel engine will draw considerably more amperage due to its higher compression ratio. Check the vehicle service manual for cranking motor test specifications.

An ampere reading lower than normal current draw could mean a discharged battery, excessive resistance in the battery and starter high-amperage cables, inside the starter or its solenoid, or in the cable connections. Crank the engine and check for voltage drops. Higher than normal amperage draw could be caused by an internal short in the starter motor or by excessive drag caused by failed engine bearings or other mechanical faults. A newly rebuilt engine will draw a bit more until it is broken in.

12. Inspect switches, connectors, and wires of starter control circuits.

Give special attention to the wiring and connections of the starter control (low-amperage) circuit. Neutral safety switches and starter solenoids under the car are subject to dripping oil, road splash, and other types of abuse.

Check all connections for tightness. If the system is acting up, perform voltage drop tests along the circuit, from the starter switch to the starter solenoid.

Theft-deterrent systems may include sensitive wiring within the steering column on certain makes of vehicles that is known to go bad. Such wiring faults can cause a no-crank condition, even if the starter and its wiring are fine.

> *Note: Troubleshooting theft-deterrent systems can be complicated, and the task goes beyond the scope of the MLR technician's on-the-job task list.*

13. Remove and replace starter.

Starter removal can be easy or difficult, depending on the make and model of the vehicle; therefore, make sure you know the starter is bad before attempting to remove and replace (R & R) it. Other components or parts may have to be removed just to gain access to starter mounting bolts/fasteners and wiring. When removing a starter, be sure to disconnect the battery first to avoid shorting the battery powered cranking circuit wiring. Be ready to support the starter once it has been unbolted; it may be heavy. Make certain any shims, if used, are saved for installation of the replacement starter.

14. Perform charging system output test and identify undercharge, no-charge, or overcharge condition.

The charging circuit can be tested by using a simple voltmeter to perform the 3-point charging circuit test:

First, check open circuit battery voltage with the engine off. Next, check battery voltage with the engine running at a fast idle and no accessories turned on. Lastly, with the engine at a fast idle, check battery voltage with all of the electrical accessories (rear defroster grid, blower on high, high-beam headlights, and fog lights) turned ON. Even with everything ON, charging system voltage read at the battery should be upwards of ~14.2 volts.

Compare the voltage readings you get against the OEM specifications. If the voltage readings are too high, suspect a faulty voltage regulator or voltage sensing wire/circuit. Make sure the alternator B+ connection is secure, not loose or burned. If voltage at the battery falls off when a load is placed on it, check the battery. If it is good, check the alternator and its wiring.

You can perform a dynamic test of the alternator and its wiring using a volt-amp tester (VAT) to place a load on the system to simulate vehicle loads. With the engine at a fast idle, watch system voltage as you dial in a load. When the system voltage starts dropping, check the amperage draw on the system. It should meet or exceed specifications. If it does not, check all charging circuit wiring for voltage drops. If good, suspect a bad alternator or regulator (or the regulator circuitry if it is externally regulated in the PCM).

15. Inspect, adjust, and replace generator (alternator) drive belts, pulleys, and tensioners.

Check the V-belts, or the serpentine belt, for aging, cracking, and stretching. Check belt tension using an appropriate test method or a tension gauge. See that the belt tensioner is operating as it should and is of the proper type (over-running). The same applies to any idler pulleys. If they are noisy or not operating correctly, replace them.

When tightening alternator mounting bolts, it may be necessary to use a heavy screwdriver to apply tension to the alternator while tightening its mountings and adjusting V-belt tension. When doing so, be extra careful to avoid breaking off the alternator mounting ears or causing damage to the alternator.

16. Remove, inspect, and replace generator (alternator).

Inspect the alternator for any physical damage. Perform a functional check of its operation. If it needs to be removed, follow the OEM instructions. Disconnect the battery, being careful not to drop it or damage the mounting ears or electrical connections. Some vehicles may require the half-axle or other components to be removed in order to remove and replace the alternator, so make sure your diagnosis is correct before calling for a replacement.

17. Inspect, replace, and aim headlights/bulbs and auxiliary lights (fog lights/driving lights).

Check for dim or burned out headlights, driving lights, and fog lights. If any are not working, first remove the non-operating bulb and check its continuity with an ohmmeter. If it is good, check the socket for voltage with the circuit or using a voltmeter. Check carefully for corrosion in the sockets. If no power is being provided, check the fuses and relays. If both lights are not working, check for a bad common ground connection.

If both headlights are dim, the battery could be low on charge or the battery connections could be dirty. If working on Xenon or high intensity discharge lamps, be extra cautious of high voltages that may be present. Follow the OEM service manual when checking these systems.

Use a headlight aiming machine for adjusting the headlights and auxiliary lights. Today's computerized machines make quick and easy work of headlight aiming–if the adjustment screws cooperate. Make certain the vehicle is on a level shop floor or driveway, that the tires are properly inflated, and that the suspension is properly aligned. The vehicle should be typically loaded and the gas tank about half full because all of these affect headlight aiming.

Some vehicles include spirit levels to assist in headlight aiming; some even have automatic headlight aiming and adjustment using servo motors. Use a scan tool to test these systems for proper operation.

18. Inspect interior and exterior lamps and sockets; repair as needed.

Check all interior lamps for correct operation. Check for proper BCM time-out functions of interior lighting. If any interior incandescent or LED lights are not working, check them. If they are burned out, incandescent bulbs can be replaced in the field. LEDs require a more in-depth repair; they must be resoldered, or a circuit board must be replaced.

Check all exterior lamps for correct operation. If an exterior light (including a headlight), is not working, first check for a burned-out bulb, then for a blown fuse. If equipped, check if a lamp out module indicates a malfunction. Check if an aftermarket trailer wiring harness has been added that may have upset power supplied to the tail or brake lights.

Check that full voltage is supplied to the light socket. If some voltage is present, the circuit is at least working so check for voltage drop on the circuit's hot side. Check for corrosion in the socket. If full voltage is present at the socket, check for a faulty ground. The problem also could be an open or a short in the wiring, or loose connections.

Check the brake lights, backup lamps, turn signals, and marker lights for proper operation. If not working, check the bulbs before starting to take things apart. Make certain the correct bulbs are installed; some look alike but have different pin configurations.

19. Inspect lenses; determine needed repairs.

If the headlight (or other) plastic lenses are cracked or broken, replace them. If the lenses look cloudy or fogged over, special kits and compounds can be used to polish them back to being nearly clear once more. If the lenses or light buckets have water collected on the inside, check for leaks where rain or snow is finding its way into the headlight (or taillight) assembly. Repair the leak, replace the gasket, or replace the light bucket assembly.

20. Verify instrument gauges, warning/indicator light operation; reset maintenance indicators.

Most warning systems rely on a grounding switch that turns the warning light on. When the switch closes, the warning light comes on. Watch the warning lights as they go through a self-test as soon as the ignition is turned on. If certain lights do not come on, they are either faulty, or the fuse to that circuit is blown.

The alternator warning light is not grounded at the instrument panel. Instead, current flows through the bulb and grounds inside the alternator. With the alternator charging, current flows through a wire to the opposite side of the bulb from the ignition switch. With both sides of the bulb receiving similar voltages, no current flows and the bulb does not light. If the alternator light glows slightly, check for a poor connection somewhere in the charging circuit.

Some maintenance indicators can be reset using a menu function on the driver's on-board information center. Others may be more involved, so be sure to follow the instructions in the vehicle service manual for specifics on resetting maintenance indicators.

21. Verify horn operation; determine needed repairs.

Operate the horn button and listen for a clear sound of the horn(s). If they fail to operate, check for a blown fuse and for faulty wiring (perhaps a rodent has chewed through the wiring). If the horn(s) is weak, check for resistance/corrosion, especially at the ground connections.

Modern vehicles activate the horn through the body control module (BCM), so using a scan tool to locate the fault may be helpful.

22. Verify wiper and washer operation; replace wiper motor, blades, and washer pump as needed.

Wet the windshield with the washer system and turn the wipers ON to make certain they operate smoothly and without streaking. Sometimes, merely cleaning debris from the rubber wiper blade insert is all that is needed to restore clear wiping action. If a wiper blade is cracked or hardened, replace the rubber insert or, better yet, the entire blade.

If the washer system fails to operate, listen for washer pump operation. If no sound is heard, check for a blown fuse or loose wiring. If the pump is working, the washer bottle may be out of fluid, or there may be a loose or cracked rubber feed hose leading to the spray heads. Check for clogged or mis-aimed spray heads; some can be cleaned and re-aimed using a straight pin.

G. Heating, Ventilation, and Air Conditioning (4 Questions)

1. Verify HVAC operation (vent temperature, blower and condenser fan, compressor engagement, blend and mode door(s) operation).

The first step in diagnosing a customer's HVAC complaint is to interview the customer and/or to carefully read the customer's concern as documented on the repair order. The next step is to put the HVAC system through its paces to make certain an actual malfunction exists. Sometimes a vehicle operator simply has not read or understood the vehicle owner's manual and therefore does not get the desired or anticipated results from the HVAC system.

The best way to check the system is to insert a thermometer probe into the center air conditioning-heating duct to make sure the system meets temperature delivery specifications. Listen for slow-to-fast blower speed operation as various selections are made. Listen for A/C clutch engagement as the A/C system or the defrost function is selected. Listen for belt noise or squealing as well. Also listen for the condenser or cooling fan(s) under the hood to turn on and off when A/C is selected or deselected.

In manual A/C systems, the temperature door is operated by a cable connected to the temperature lever, or by a vacuum motor.

In a semi-automatic A/C system, the temperature door is operated by an electric motor that is controlled by a module. The module receives inputs from the variable resistor connected to the temperature lever, the in-car sensor, and the outside air temperature sensor.

In an automatic A/C system, the temperature door, mode doors, blower speed, and compressor clutch are all operated by the climate control system's computer.

When putting the HVAC system through its paces, listen for the hissing of vacuum leaks or check for sticking or hard to operate Bowden cables.

2. Visually check A/C components for signs of leaks.

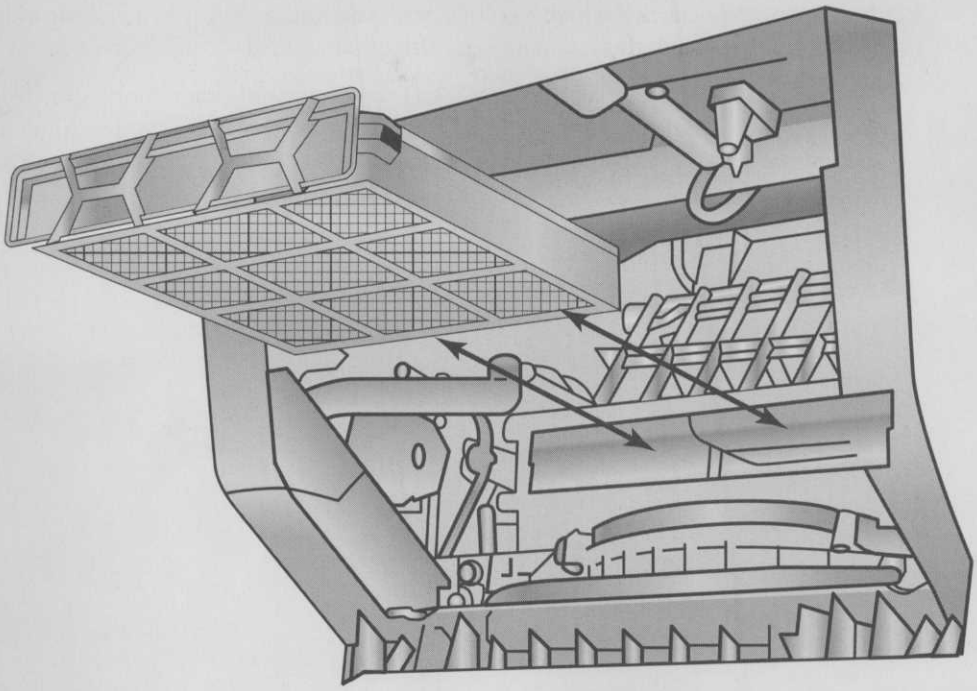
A/C systems can leak refrigerant over time either through tubing and their connections, or due to older, more porous, flexible A/C hoses. The telltale sign of refrigerant leakage is oil stains that appear at any of these locations, on the fins of the condenser, or elsewhere.

3. Inspect A/C condenser for restricted air flow.

The A/C condenser is typically located in front of the cooling system radiator. It is the first place leaves, bugs, and other debris can collect and block air flow through the condenser and the radiator. If any blockage exists, it must be cleared for both the A/C and the engine cooling system to work effectively.

4. Inspect and replace cabin air filter.

Many vehicles now include a cabin air filtration system to help keep incoming cabin air clean and free of debris (leaves, etc.) pollen and bacteria. Filters are not normally cleaned or reused beyond their recommended life. Maintenance schedules call for periodic replacement of cabin air filters, which are normally located under the passenger's side dashboard by the blower assembly. Some vehicles may require modifications to the dashboard facia in order to remove the filter for the first time. Alternatively, the filter may be located on the firewall under the hood or accessed outside from below the windshield wipers. Replacement involves sliding out the old paper filter and inserting a new replacement filter.



Replacing the cabin filter is often done from below the glove box. On other models they may accessed from the outside below the windshield.

5. Check drive belt for wear and tension; adjust or replace as needed.

While some more modern vehicles (including hybrids) use electrically driven A/C compressors, most A/C systems use engine-driven drive belts to rotate the A/C compressor. Older vehicles use V-belts; newer vehicles drive the compressor from the serpentine drive belt. Inspect these belts for wear, cracks, contamination, or looseness.

Gauges used for checking belt tension and serpentine belt wear are part of the MLR technician's toolbox. Serpentine belt manufacturers tell us that modern belt composition does not show the usual signs of dryness and cracking as they age. The proper way to test serpentine belts is by using a wear gauge. Belt tension is often done automatically by the tensioner, but older vehicles may require periodic tightening of the V-belt pulley to specifications. Make certain the serpentine belt has not jumped a groove on any of its pulleys and it is running in perfect alignment. If a complaint of a belt jumping from its pulley is heard, check for stuck, frozen, or misaligned pulleys along with proper tension.

When replacing belts, follow the routing guide typically found on a sticker under the vehicle's hood or in the service manual. Often when replacing a serpentine belt, it is a good idea to replace the tensioner at the same time.

6. Inspect and clean evaporator drains.

Condensate from the A/C evaporator must somehow exit the HVAC blower box below the dashboard and exit to the road. If leaves or dust have accumulated in the bottom of the box, the rubber tube leading to the outside may become clogged, causing a backup of water in the box. With the blower on HIGH, check for droplets of water spitting out of the heater vents or for emissions of foul smelling air. Also with the A/C on max setting look for water dripping on the front passengers floor.

In extreme cases, debris which has collected in the heater box may cause the evaporator to leak and cause the A/C system to lose refrigerant and fail.

The best way to prevent such failures is to keep leaves and other debris away from the cabin air inlets (near the windshield wipers) and to periodically clear the condensate tube exiting the firewall or from below the vehicle carefully (do not pierce the evaporator) with a stiff piece of wire.