



AUTO BODY REPAIR

BODY ALIGNMENT



TEACHER'S GUIDE

SHOPWARE®

INTRODUCTION

This Teacher's Guide provides information to help you get the most out of *Body Alignment*. The contents in this guide will enable you to prepare your students before using the program and present follow-up activities to reinforce the program's key learning points.

As part of the 12-part series *Auto Body Repair*, the *Body Alignment* video provides an overview of the types of frame damage commonly found, and identifies basic wheel alignment angles. The program outlines procedures to properly align a damaged frame, and to correct misalignments in steering and suspension systems, with an emphasis on equipment and safety. After viewing this video and completing some of the learning activities included in this guide, students will be better prepared to properly align and repair frames as well as adjust steering systems, tires, and wheels. Use the *Body Alignment* video and accompanying activities provided in this guide to teach students how to pull a frame back into alignment, how to use tire clues and other evidence to identify and fix misalignments of unitized and conventional frames, and how to make adjustments to steering systems, as well as to tires and wheels.

LEARNING OBJECTIVES

After viewing the program, students will be able to:

- Describe the five different types of frame damage.
- Demonstrate a basic knowledge of body alignment repair operations and safety procedures.
- Explain procedures for correcting frame damage.
- Identify the correct tools to use given the task to be performed.
- Identify the five basic wheel alignment angles.
- Inspect tires and diagnose sources of misalignment, and determine needed adjustments.

EDUCATIONAL STANDARDS

The primary certifying body for automotive technician training programs is the National Institute for Automotive Service Excellence (ASE). ASE is a non-profit organization established in 1972 by the automotive industry to improve the quality of vehicle repair and service through the voluntary testing and certification of automotive repair technicians. The National Automotive Technicians Education Foundation (NATEF) is a separate non-profit foundation within ASE. The mission of NATEF is to improve the quality of automotive technician training programs nationwide through voluntary certification. The State Departments of Education in all 50 states support ASE/NATEF certification of automotive programs.

National Standards

This program correlates with the Program Certification Standards for Automobile Technician Training Programs from the National Institute for Automotive Service Excellence (ASE) and the National Automotive Technicians Education Foundation (NATEF). The content has been aligned with the following educational standards, which reflect the tasks in the ASE Program Certification Standards for Automobile General Service Technician Programs.



Frame Inspection and Repair

- Attach frame-anchoring devices.
- Straighten and align mash, sag, sidesway, twist, or diamond frame damage.
- Identify misaligned or damaged steering, suspension, and powertrain components that can cause vibration, steering, and wheel alignment problems; align or replace in accordance with vehicle manufacturer's specifications/procedures.

Unibody Inspection, Measurement, and Repair

- Recognize that measuring, dimensioning, and tolerance limits in unibody vehicles are critical to the repair of these vehicles; recognize that suspension/steering mounting points and engine power train attaching points are critical to vehicle safety, handling, and performance.
- Determine and inspect the locations of all suspension, steering, and powertrain component attaching points on the body.
- Diagnose and measure unibody vehicles using a dedicated (fixture) measuring system.
- Attach body-anchoring devices; remove or reposition components as necessary.

Suspension and Steering

- Inspect alignment, adjust tension, and replace power steering pump belts.
- Inspect axle assembly for damage and misalignment.
- Measure vehicle ride height; determine needed repairs.
- Adjust front and rear wheel camber on suspension systems with camber adjustments.
- Check front and rear wheel camber on adjustable and non-adjustable suspension systems; determine needed repairs.
- Adjust caster on suspension systems with caster adjustments.
- Check caster on adjustable and non-adjustable suspension systems; determine needed repairs.
- Check and adjust wheel toe; determine needed adjustment or repair.
- Identify toe-out-on-turns (turning radius) related problems; determine needed repairs.
- Identify SAI (steering axis inclination)/KPI (king pin inclination) related problems; determine needed repairs.
- Identify thrust angle related problems; determine needed repairs.
- Check for front wheel setback; determine needed repairs.
- Diagnose tire wear patterns; determine needed repairs.
- Inspect tires, identify direction of rotation, and location; check and adjust air pressure.
- Diagnose wheel/tire vibration, shimmy, and tramp (wheel hop) problems; determine needed repairs.
- Diagnose tire pull (lead) problems; determine corrective actions.

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Language Arts and Communication Standards

According to ASE/NATEF standards, the automobile technician must be proficient in the following Language Arts and Communications related academic skills that are embedded in the occupation. The activities and information presented in this program and accompanying teacher's guide are aligned to the following standards from the National Automotive Technicians Education Foundation from the National Institute for Automotive Service Excellence.

- Request, collect, comprehend, evaluate, and apply oral and written information gathered from customers, associates, and supervisors regarding problem symptoms and potential solutions to problems.
- Identify the purpose for all written and oral communication and then choose the most effective strategies for listening, reading, speaking, and writing to facilitate the communication process.
- Adapt a reading strategy for all written materials, e.g. customer's notes, service manuals, shop manuals, technical bulletins, etc., relevant to problem identification, diagnosis, solution, and repair.
- Use study habits and techniques, i.e. previewing, scanning, skimming, taking notes, etc., when reviewing publications (shop manuals, references, databases, operator's manuals, and text resources) for problem solving, diagnosis, and repair.
- Use prior knowledge learned from solving similar problems to diagnose and repair specific problems.
- Write clear, concise, complete, and grammatically accurate sentences and paragraphs.
- Write warranty reports and work orders to include information regarding problem resolution and the results of the work performed for the customer or manufacturer.
- Follow all oral/written directions that relate to the task or system under study.
- Comprehend and apply industry definitions and specifications to diagnose and solve problems in all automotive systems and components of the automobile and light truck.
- Comprehend and use problem-solving techniques and decision trees that are contained in service manuals and databases to determine cause-and-effect relationships.
- Use the service manual to identify the manufacturer's specifications for system parameters, operation, and potential malfunctions.
- Interpret charts, tables, or graphs to determine the manufacturer's specifications for systems operation to identify out-of-tolerance systems and subsystems.
- Use English and metric angle and distance measurements and techniques to determine parallel lines, perpendicular lines, and angle variances from the manufacturer's specifications.
- Visually perceive the geometric relationship of systems and sub-systems that require alignment.
- Use formulas to indirectly confirm that systems are outside of the manufacturer's specifications.
- Follow all safety regulations and procedures while performing any task.

Technology Standards

The activities in this Teacher's Guide were created in compliance with the following *National Education Technology Standards* from the National Education Technology Standards Project. The content has been aligned with the following educational standards and benchmarks.



- Use a variety of media and formats to communicate information and ideas effectively to multiple audiences.
- Use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences.
- Use productivity tools to collaborate in constructing technology-enhanced models, prepare publications, and produce other creative works.
- Use technology tools to enhance learning, increase productivity, and promote creativity.
- Use technology to locate, evaluate, and collect information from a variety of sources.

The National Education Technology Standards *reprinted with permission from the International Society for Technology Education.*

PROGRAM OVERVIEW

Proper alignment is critical to the safe operation of any vehicle, especially one that has sustained damage to its frame, and its steering and suspension systems. This video, *Body Alignment*, demonstrates techniques to properly align and repair frames as well as adjust steering and suspension systems, tires, and wheels. Students will have the opportunity to see actual technicians straighten a damaged frame using frame-straightening equipment. They'll also take an up-close look at the tools used to make corrective adjustments to steering and suspension systems. After viewing this program, students will have a much better understanding of the visible characteristics of frame and wheel misalignment and the corrective measures necessary to restore a vehicle to pre-accident condition.

MAIN TOPICS

Topic 1: Types of Frames and Damages

This section of the program describes the two primary frame designs – unibody and body-over-frame – and their major structural parts, as well as the five basic types of damages both frame styles suffer, including visible damage characteristics.

Topic 2: Frame Alignment and Safety Practices

This section begins by discussing the importance of taking frequent measurements, and practicing safety measures when using frame alignment equipment. The technique of pulling a frame back into alignment is demonstrated using a frame rack and other equipment. Students will learn the overall steps in the pulling procedure and the critical need for frequent measuring throughout the straightening process.



Topic 3: Wheel Alignment

This section of the program describes the five basic wheel alignment angles, including positive and negative characteristics of each one, corrective measures, and operational variations for front-wheel and rear-wheel drive vehicles. Students will learn how to make final adjustments to the steering and suspension systems, and the importance of tire inspection to determine possible sources of improper alignment.

FAST FACTS

- Most vehicles are constructed with one of two major frame types: unibody, or conventional body-over-frame (B-O-F). In assessing and repairing frame damage, it is important to know what kind of frame the vehicle has, and its various parts.
- In a body-over-frame vehicle the frame provides the structure of the car, while the panels are mostly cosmetic. In a body-over-frame, the major parts are the stud frame section, the front cross member, the side rail, and the rear cross member.
- In a unibody vehicle, the body panels are welded together to help create the structure of the car. In a unibody vehicle the major parts are the header bar, windshield, pillar, strut tower, front rail, front body, hinge pillar, rocker panel, and center panel.
- Frame damage is classified into the following five categories: *sidesway, sag, mash, diamond, and twist*.
- Use control or reference points for making measurements when repairing frames. A vehicle is not repaired properly until the measurements for these reference points are returned to the vehicle's original dimensions, which can be found in a body alignment book.
- The body frame must be properly aligned before you can adjust the wheels or suspension.
- Aligning the frame is a demanding process that requires carefully applied force and frequent measurement during each straightening step.
- A frame is straightened by pushing or pulling it back into alignment.
- Pulling refers to using special equipment to stretch the damaged metal back into place. It is most often done by securing the vehicle to a rack and then attaching clamps and chains to the damaged part. The chains are connected to a hydraulic system that slowly pulls the vehicle back into its original shape. Measurements are made until the reference points match the original dimensions.
- Relatively minor damage usually calls for one pull using one chain; severe damage may call for multiple chains pulling in different directions.
- Carefully measure during the pulling process to avoid over-pulling the metal, which is a costly mistake!
- Safety is a must when using frame-pulling equipment. Improper usage of equipment may lead to pulling the vehicle off the rack, among other things. And using improper chain size or grade can cause chains to snap.
- A single hard pull will result in tearing of metal before straightening occurs. Multiple pulls are usually needed to correct an alignment problem.
- When preparing to pull a vehicle, never attach clamps to mechanical or suspension parts unless those parts are going to be replaced!



- Once all straightening operations are complete, make final alignment checks by referencing the body dimensions book, and visually inspecting parts, fixtures, and gaps on rooflines and doors.
- The basic wheel alignment angles are *caster*, *camber*, *toe*, *steering axis inclination (SAI)*, and *thrust*.
- Rear wheel drive vehicles are often adjusted to have slight toe-in at the front wheels to compensate for play in the steering system and suspension action. Tires on rear wheel drive vehicles tend to toe-out while driving, and a small amount of toe-in adjustment will cause them to roll straight.
- Front wheel drive vehicles need to have their front wheels set for dead ahead or with a very slight toe-out. The front wheels can be forced inward by drive train torque on a front wheel drive car. A very slight toe-out will keep them straight while driving.
- Using structural measurements and measuring steering axis inclination (SAI), auto body repair technicians can diagnose strut tower misalignment, shifted engine cradle, control arm damage, and misaligned frame or body structure.
- Inspecting tires can indicate low tire pressure, a broken spring, or other suspension problems.
- If one side of the tire tread is worn, it may indicate low air pressure, camber, or toe problems.
- Tires that are not inflated to the correct air pressure will cause steering and handling problems, and accelerated or uneven tire wear. The owner's manual or driver side doorframe list the correct air tire pressure for the vehicle.
- Once wheel alignment angles or problems have been fixed, the final step is to road test the vehicle to make sure that the vehicle doesn't pull, vibrate, or exhibit any other indications of alignment problems.

VOCABULARY TERMS

anchoring: Technique to secure a body-over-frame vehicle to a frame rack with chains and blocking, or clamps.

body-over-frame (B-O-F) construction: Vehicle frame construction typically found in pickup trucks, vans, SUVs, and full-size luxury vehicles, where the frame provides the structure of the car. Body parts, such as the drive train and mechanical accessories, are bolted rather than welded or bonded to the frame.

camber: The angle or tilt (lean) of the wheels inward or outward from the vehicle's centerline when viewed from the front of the vehicle, typically affected by worn or loose ball joints, control arm bushings, and wheel bearings. Signs of camber problems include the vehicle pulling to one side (the one with more positive camber or possibly less air in the tire) and uneven tire wear across the tread.

caster: The angle of the steering axis (pivot) of a wheel from true vertical when viewed from the side. It is a directional stability adjustment and is measured in positive or negative degrees. Signs of caster problems include the vehicle pulling to one side (the one with less positive caster). Signs of too much positive caster are heavy steering, and wheel hopping over bumps; a sign of too much negative caster includes light steering with excessive steering wandering.



diamond damage: Frame damage that is caused by impact to one corner of the car, resulting in the unibody or frame being pushed out of square. Diamond damage on a unibody vehicle usually results in a total loss.

frame rack: A metal apparatus onto which a damaged vehicle is placed that is used in conjunction with heavy chains and clamps to stretch metal using a hydraulic puller.

jack stand: A heavy piece of metal equipment that is placed underneath a vehicle. It is used to stabilize a vehicle when placed on frame alignment equipment.

mash damage: Localized frame damage that is generally limited to the front or rear of the vehicle, characterized by any one section of the car being shorter than factory specifications; it is typically identified by severe distortion of the fenders, hood, and possibly the frame horns.

negative camber: When the top of the wheel is tilted inward, and more of the inner tire tread contacts the road surface.

pinch weld clamps: Components used to secure (anchor) a unibody vehicle to a frame rack.

positive camber: When the top of the wheel is tilted outward, so that the outer edge of the tread contacts the road.

pulling: Frame straightening technique to stretch damaged metal back into place using special equipment. Often done by securing the vehicle to a rack and then attaching clamps and chains to the damaged part. The chains are connected to a hydraulic system that slowly pulls out the damage. Measurements are made until the reference points match the original dimensions.

ride height: A measurement from a level surface to a predetermined point on the wheel or suspension.

sag damage: Frame damage in which one section of the frame is lower than normal. Caused by a direct impact to the front or rear of the vehicle, which can be detected by a gap between the fender and door that narrows towards the top.

set back: A condition in which one front wheel is moved back so that there is an unequal wheelbase between the left and right sides of the vehicle. Typically caused by impact to a front wheel assembly that moves a control arm, engine cradle, or suspension rod backwards.

sidesway damage: Frame damage that is caused by a side impact which results in side bending of the frame. Often recognized by a gap in the door on the long side and buckles on the opposite side.

steering axis inclination (SAI): The angle between true vertical and the line through the upper and lower steering pivot points when viewed from the front; an engineering angle designed to project the weight of the vehicle to the road surface for stability.

suspension: An assembly used to support weight, absorb and dampen shock, and help maintain tire contact and proper wheel-to-chassis relationships.

thrust angle: An imaginary line between the vehicle's centerline and the rear axle. Positive thrust angle projects to the right of the vehicle centerline when viewed from the top; negative thrust projects to the left of the vehicle centerline. If the rear toe is not parallel to a vehicle centerline, a thrust direction will be created, and the vehicle will tend to travel in the direction of this thrust rather than in a straight line.

toe: The difference in the distance between the front and rear of the left-hand and right-hand wheels, measured in inches or millimeters. Toe adjustment is critical to tire wear. Proper toe makes the wheels roll in the same direction. If toe is out of spec, then one tire or all tires are being dragged sideways, causing rapid tire wear.



toe-in: Condition that is caused when the front of the wheels are set closer in than the rear. With toe-in, the wheels are “pigeon toed”, or point in at the front.

toe-out: Condition that is caused when the front of the wheels point out, or are farther apart on the front than the rear.

twist damage: Frame damage that is generally caused by hitting a curb or median at high speeds, resulting in one corner or side of the vehicle being higher than another; typically detected by a low or sagging corner, as if the suspension were broken.

unibody construction: Vehicle frame construction typically found in passenger cars; metal body panels are welded together to form the structure of the vehicle, rather than the frame.

PRE-PROGRAM DISCUSSION QUESTIONS

1. Which sections of a vehicle are vulnerable to alignment problems?
2. How do you think a damaged frame is straightened?
3. Can you identify the tell-tale clues that indicate possible alignment problems?
4. What can happen as a result of an improper alignment or misalignment from an accident?
5. Do you think damage to a frame can result in the vehicle being declared a total loss? Why or why not?

POST-PROGRAM DISCUSSION QUESTIONS

1. Now that you have seen the *Body Alignment* video, can you explain why chains should be covered with a heavy blanket during the pulling process?
2. As a group, list the five basic types of wheel alignment angles and the distinguishing clues that indicate alignment problems.
3. Why is it critical to frequently measure the stretched metal throughout the pulling process?
4. How is a body-over-frame vehicle anchored to a frame rack? How is a unibody vehicle anchored to a frame rack?
5. What is the final step after repairing frame and wheel alignment problems? Why is this step critical to the entire alignment process?

GROUP ACTIVITIES

Charades

The *Body Alignment* video presented concepts about types of frame designs and damages, frame alignment and safety practices, and wheel alignment angles, including:

- Five categories of frame damage: sidesway, sag, mash, diamond, and twist, including physical characteristics



- Measurement (of frame during straightening process)
- Final checks (referencing the body dimensions book, visually inspecting parts, fixtures, and gaps on rooflines and doors)
- Five basic wheel alignment angles: caster, camber, toe, steering axis inclination (SAI), and thrust, showing how to identify each
- Tire inspection: worn treads, low air pressure, broken spring or other suspension problems

The idea of this activity is for a group member to act out the chosen concept through the use of pantomime without speaking, writing, touching, or pointing at an object. Participants may use signals (nodding their head for Yes or No, holding up fingers to indicate the number of syllables in a word, holding hands together or far apart to indicate the word is long or short). On a separate piece of paper, jot down a word or phrase related to the concepts above. Divide the class into groups. Instruct participants to take turns selecting and acting out a concept for two minutes for his/her group to guess. Team members guess by shouting out a word or phrase. Correct answers earn one point. If group members do not guess the concept within the allotted time, the other teams will have an opportunity to guess and earn additional points for their team. The instructor will keep score using a stopwatch or egg timer. The team with the highest score wins.

Damage: Up Close and Personal

Structural damage is classified into the following five categories: sidesway, sag, mash, diamond, and twist. Your group has been asked to appear on the show *Meet the Damage* for a segment on structural damage. As a group, prepare a list of the characteristics of each type of damage, and any other pertinent information you can find out about each category. Consult the *Body Alignment* video, the Internet, and any other sources that you have available. You can even include photographs. After gathering all the information as a group, randomly assign one category to each group member, including the role of Host. (Group members can jot down each category/Host role on a separate piece of paper, shuffle them, and take turns picking a category until all categories have been assigned. If there are more categories than group members, one group member can represent two categories.) The Host will begin the segment by introducing each damage category and invite each one to tell the audience a little about himself/herself. The Host will then invite audience members to ask the guests creative questions. For example, an audience member can ask a question such as, “When your condition has been diagnosed, what is the prognosis for a full recovery?”

Safety First

Serious injury can result from inattention to safety in an auto body repair shop. The *Body Alignment* video presented some basic safety “dos” and “don’ts” when using straightening equipment. Do you remember them? As a group, list as many safety tips that should be followed when operating frame-straightening equipment. Reference the *Body Alignment* video, the Internet, safety manuals, etc. As a group, create a comic strip that illustrates the characters learning about or practicing safety measures when straightening a damaged frame on a rack. For example, you may include an experienced comic strip technician teaching an inexperienced comic strip technician frame alignment rules.



INDIVIDUAL STUDENT PROJECTS

Field Trip

Prepare a list of local auto body shops that specialize in frame straightening. Then, visit the shops to make an appointment to observe a frame being straightened (but bear in mind that many shops do not permit non-employees in the actual bay area due to insurance liability.) After securing an appointment to observe the frame straightening process, write down everything you observe the auto body repair technician doing. Take photos if you are permitted to do so. Then, prepare a written report, with photographs, describing what you've learned about the frame straightening process. Was there something you learned or observed that was not in the *Body Alignment* video? Were there any tasks that were performed in an unsafe manner? What technique were you most impressed with? What did you observe other people doing while watching the auto body repair technician? Be sure to include all your observations, including conversations with all body shop employees, in your report.

Tech Trivia

Alignment technology continues to evolve as auto body repair technicians rely on computer diagnostics and digital tools and equipment to aid them during the alignment process. Research alignment technology using auto magazines, the Internet, and any other resources you can think of. Create five multiple choice questions that will challenge the trivia skills of your classmates regarding the role of technology in the alignment process. Make sure you include an answer key and cite the source from which you obtained the questions.

Safety Guide

There are many safety rules that must be observed when straightening a frame on a frame rack using chains and clamps. Review the rules taught in the *Body Alignment* video, research safety rules in other places such as books and on the Internet, and, if possible, visit an auto body shop that specializes in frame straightening and write down the safety rules observed in that shop. After completing your research, prepare a two-page safety guide that describes the rules that should be observed in the auto body shop; illustrate your guide with pictures to help readers remember the rules.

INTERNET ACTIVITIES

Alignment Angles

The *Body Alignment* video discussed the five basic wheel alignment angles. Review the angles taught in the video, and in other places such as books and on the Internet. For this activity, prepare a poster that includes brief descriptions/illustrations of the following items for each wheel alignment angle:

- Definition or description of angle
- How it is measured (if applicable)
- Visual characteristics or clues of angle problems (if applicable)
- Diagram illustrating angle concept

You may want to visit <http://www.tirerack.com/tires/tiretech/general/align.jsp> to get started.



Discover Alignment

There are many facets to a vehicle's suspension system and wheel alignment. Gain a better understanding of the alignment process by exploring the links within the Web site <http://www.advanceautoparts.com> to learn more about tires, suspension, and steering, to name a few. Write down then new things you learned about suspension, steering, and alignment by exploring this Web site. To get you started, you can visit the following related link within the Web site to view a step-by-step process of toe adjustment, which often causes excessive tire wear if not corrected.

<http://www.advanceautoparts.com/english/youcan/html/ccr/ccr20021201ay.html#>

Discussion Forums

Visit www.autobodyonline.com and enter the discussion forums by clicking the "Discussion" tab in the upper left corner of the web page. Post a question about frame straightening or wheel alignment. Ask about problems that are most common or often overlooked. Also, review the other posts within the forums and see if you can gather any other information about diagnosing or performing an alignment. After a week, copy all your responses, as well as any other posts you have seen that are relevant, into a word processing document. Then answer the following questions: What have you learned as a result of the answers you have received to your post? What have you learned from reading other posts? Did any of the responses conflict with one another? If so, what issues did they raise?

ASSESSMENT QUESTIONS

Q: Pulling a vehicle is most often done by securing the vehicle to a frame rack and then attaching chains to the damaged part with bolts, clamps, and adapters. Technician A says that pinch weld clamps can be attached to any point on a unibody that can withstand the force of the pull. Technician B says that pinch weld clamps should never be attached to mechanical or suspension parts on a unibody unless those parts are going to be replaced. Who is correct?

- (a) Technician A
- (b) Technician B
- (c) Both A and B
- (d) Neither A nor B

A: (c)

Feedback: Both A and B are correct. "Pulling" refers to using chains that are connected to a hydraulic system to slowly stretch the damaged metal back into place. Pulling is most often done by securing the vehicle to a rack and then attaching chains to the damaged part with bolts, clamps, and adapters. On a unibody vehicle, pinch weld clamps can be attached to any point that can withstand the force of the pull. However, clamps should never be attached to mechanical or suspension parts unless those parts are going to be replaced.



Q: Which one of the following types of damage occurs when the frame or unibody is pushed out of square?

- (a) twist
- (b) mash
- (c) sideways
- (d) diamond

A: (d)

Feedback: Diamond damage occurs when one corner of the car has been hit and the frame or unibody is pushed out of square. Diamond damage on a unibody vehicle usually results in a total loss.

Q: Which one of the following statements about steering axis inclination (SAI) is FALSE?

- (a) SAI is an engineering angle designed to project the thrust of the vehicle forward.
- (b) SAI is a good indicator of alignment problems since it will generally signify damage to the vehicle's structure, or to certain parts.
- (c) SAI helps the steering system return to straight after a turn.
- (d) SAI is not a service adjustment; it is a check for damaged or bent parts.

A: (a)

Feedback: All of the statements are TRUE except for (a). SAI is an engineering angle designed to project the weight of the vehicle to the road surface for stability.

Q: Which one of the following statements describes camber?

- (a) Camber is the imaginary line between the vehicle's centerline and the rear axle.
- (b) Camber is the parallelism of a pair of wheels when viewed from above.
- (c) Camber is the tilt of the wheels inward or outward from the vehicle's centerline when viewed from the front of the vehicle.
- (d) Camber is the angle of the steering axis of a wheel from true vertical when viewed from the side of the vehicle.

A: (c)

Feedback: Camber is the tilt of the wheels inward or outward from the vehicle's centerline when viewed from the front of the vehicle; it is not the parallelism of a pair of wheels when viewed from above. Thrust is the imaginary line between the vehicle's centerline and the rear axle. Caster is the angle of the steering axis of a wheel from true vertical when viewed from the side.

Q: Relatively minor damage only requires a single pull, with just one chain being attached to the damaged part of the vehicle. (*True or False*)

A: True

Feedback: Severe damage requires multiple pull operations; several chains in different pulling directions are needed.

Q: Technician A says that proper wheel alignment depends entirely upon adjustments. Technician B says that other factors, such as ride height, affect alignment. Who is correct?

- (a) Technician A
- (b) Technician B
- (c) Both A and B
- (d) Neither A nor B



A: (a)

Feedback: Technician A is correct. Wheel alignment involves the final adjustment of the steering and suspension systems to make the wheels roll properly over the road surface. Ride height is simply a measurement from a level surface to a predetermined point on the wheel or suspension; it is an indirect method to determine spring height, which is important because it affects camber, caster, and toe.

Q: During a pull, cover the chain with a _____ when appropriate to prevent the chain from being thrown across the shop if it breaks.

A: heavy blanket

Feedback: Never stand in a place where a chain might hit you if it snaps during a pull. Cover the chain(s) with a heavy blanket, when appropriate. This will prevent the chain from being thrown across the shop if it breaks.

Q: What is the general rule regarding removal of bolts on parts and weld-on parts when beginning a pull?

A: Only remove bolts on parts and weld-on parts if absolutely necessary!

Feedback: As a general rule, avoid removing bolts on parts and weld-on parts unless absolutely necessary. Remove only the bolt on parts that prevent you from getting to an area when beginning a pull.

Q: Technician A says that steering axis inclination is the most critical alignment setting relative to tire wear. Technician B says that toe adjustment is the most critical alignment setting relative to tire wear. Who is correct?

- (a) Technician A
- (b) Technician B
- (c) Both A and B
- (d) Neither A nor B

A: (b)

Feedback: Toe adjustment is the most critical alignment setting relative to tire wear. If properly adjusted, toe makes the wheels roll in the same direction. If toe is out of spec just a little bit, then one tire or all tires are being dragged sideways, resulting in rapid tire wear.

Q: Irregular tire tread wear is only caused by either camber or toe problems. (*True or False*)

A: False

Feedback: Irregular tire tread wear, such as wear on only one side of the tire tread, may indicate low air pressure, camber, or toe problems.



ADDITIONAL RESOURCES

WEB SITES

Auto Body Online

www.autobodyonline.com

Auto Body PI

www.autopi.com/frame.htm

Auto Body Pro

www.autobodypro.com

Auto Body Tool Mart Repair and Restoration Tutorials

www.autobodytoolmart.com/restorations.html

Automotive Body Repair News

www.abrn.com/abrn

Auto Glossary

www.autoglossary.com

Auto Inc. Online

<http://www.autoinc.org>

Automotive Services Association

www.asashop.org

Automotive Youth Educational Systems (AYES)

www.eyes.org

Collision Repair Industry Insight

www.collision-insight.com

How Stuff Works—Auto Stuff Page

<http://auto.howstuffworks.com>

I-car

www.i-car.com

National Automotive Service Task Force

www.nastf.org

National Automotive Technicians Education Foundation

www.natef.org



Society of Collision Repair Specialists

www.scrs.com

Tektips—Auto Body Pro Website

www.autobodypro.com/tektips.htm

BOOKS

Duffy, James E. *I-CAR Professional Automotive Collision Repair*. Albany, NY: Delmar Thomson Learning, 2001. ISBN: 0766813991

Duffy, James E. *Auto Body Repair Technology, 4th Edition*. Clifton Park, NY: Thomson/Delmar Learning, 2003. ISBN: 0766862747

Killingsworth, Jeff, Eric Godfrey, and John H. Haynes. *The Haynes Suspension, Steering And Driveline Manual*. Newbury Park, CA: Hayes North America, 1998. ISBN: 1563922932

Scharff, Robert, and James E. Duffy. *Motor Auto Body Repair, 3rd Edition*. Albany, N.Y.: Delmar Publishers, 1998. ISBN: 0827368585

OTHER PRODUCTS

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