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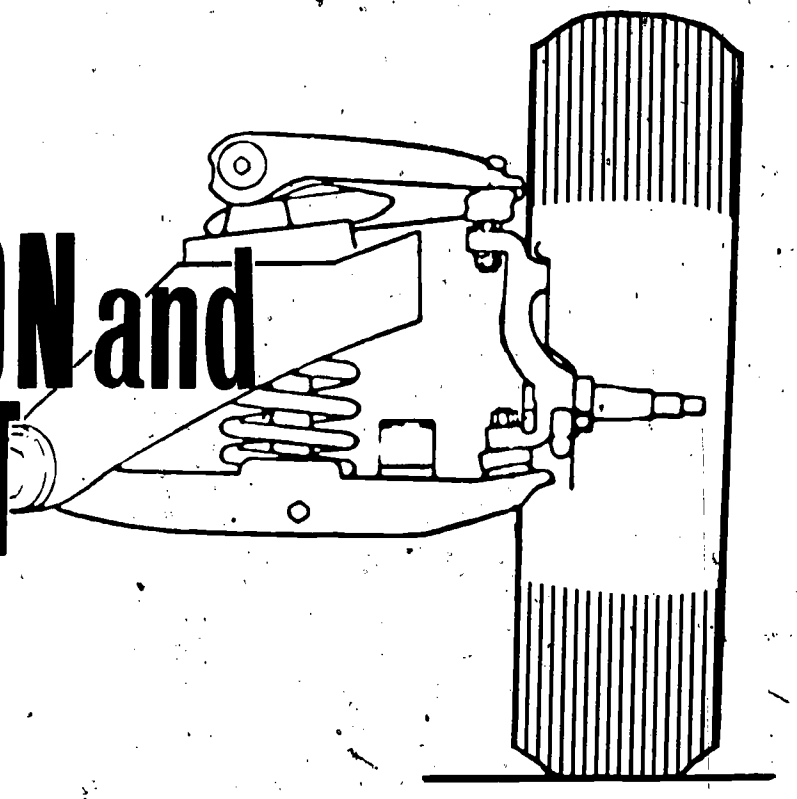
ABSTRACT

Designed to assist instructors in preparing secondary and adult students for employment in the field of suspension and alinement services, this guide outlines five units of instruction. The five unit titles are: (1) Introduction (overview of course content and requirements, and work/safety habits), (2) Suspension Service and Repair, (3) Wheel Alinement, (4) Wheel Balance, and (5) Manual and Power Steering. Methods and materials are suggested for enriching the course and achieving a more effective presentation. A two-column format is used: the left-hand column contains suggested topics which are keyed to specific objectives; the right-hand column gives related factual information, as well as instructional suggestions and page references for selected textbooks. At the conclusion of each unit, topics for review discussion are included. A sample final examination is also provided. A list of suggested aids is given in the bibliography: Textbooks, reference books, booklets and charts, films, filmstrips, slides, film loops, and transparencies. (HD)

AN INSTRUCTOR'S GUIDE FOR A PROGRAM IN



SUSPENSION and ALINEMENT SERVICES

TRADE AND TECHNICAL EDUCATION

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THE UNIVERSITY OF THE STATE OF NEW YORK / THE STATE EDUCATION DEPARTMENT
BUREAU OF CONTINUING EDUCATION CURRICULUM DEVELOPMENT
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FOREWORD

Suspension and Alinement Services was developed from the suggested services for automotive springs, shocks, stabilizing devices, front suspension, and steering that are listed in the *Automotive Services Occupations*. The content may be used in secondary schools and adult programs to assist in preparing individuals who wish to enter the automotive field or to upgrade personnel already working as automotive mechanics.

Appreciation is expressed to Fred W. Gramet, automotive team leader, Nassau County BOCES, Jericho, for the development of the original instructional materials. Additional information was contributed by Wallace Chapman, auto mechanics instructor at Hudson Valley Community College, Troy. Assistance relating to content was provided by Charles A. Stebbins, associate in the Bureau of Trade and Technical Education. The project was coordinated and the manuscript prepared for publication by Nelson S. Maurer, associate in the Bureau of Continuing Education Curriculum Development.

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MESSAGE TO THE INSTRUCTOR

Suspension and Alinement Services is designed to prepare students for employment in a specialized area of automotive services. Units are presented in numerical order, but the sequence may be altered to accommodate the needs and backgrounds of the trainees. The availability of tools and equipment also may necessitate adaptations in the use of the materials.

This guide suggests methods and materials that should enrich a course and help achieve a more effective presentation. The general objectives for each unit are stated in terms of performance activities that the student is able to do as a result of the instruction. The standards, as determined by the instructor, should be at least the minimum proficiency necessary for entry employment in the area of suspension and alinement services. More detailed objectives may be developed and these also should be stated as observable behavior that the learner is able to do when applying the skills and knowledges acquired. The left-hand column of each unit contains a suggested topical outline; the right-hand column gives related factual information, as well as suggested teaching techniques and page references for selected textbooks. At the conclusion of each unit, topics for review discussion are included. Also, a sample final examination is provided.

The use of instructional aids will greatly clarify the presentation of the material. A list of suggested aids is given in the bibliography. Excellent instructional materials are available from various automobile and automotive equipment manufacturers. Local dealers will often donate service instructional materials after they have presented the information to their own mechanics. Specific items may be located in *Automotive Instructional Material* published by the Automotive Service Industry Association. Many useful teaching aids may be fabricated from samples or discarded equipment.

New instructional aids are constantly being made available to instructors. Current releases of audiovisual aids are usually listed in issues of such publications as *American Vocational Journal*, *Industrial Education*, and *School Shop*. New information relating to the automotive industry is available from automotive trade magazines and automotive enthusiasts publications.

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CONTENTS

INTRODUCTION

OBJECTIVES

The student will be able:

- To assess the value of the course in meeting his perceived occupational needs
- To demonstrate appropriate work habits and attitudes during training and on the job
- To demonstrate a high regard for the safety of himself and his fellow workers during training and on the job
- To explain briefly the evolution of suspension and steering systems from the wagon to the modern car
- To identify and explain the operation of the component parts of the suspension and steering systems
- To explain how the suspension, steering, and alinement of a vehicle affect its handling characteristics

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
I. Importance of Suspension and Alinement Service	Indicate that to keep the original handling qualities of a vehicle and to get maximum tire wear periodic wheel alinement and service to the suspension system are necessary. Furthermore, new tire designs and increased highway speeds have emphasized the desirability of maintaining the suspension system at or near the original specifications. Also, the condition of the tires and the suspension system are included in the required annual vehicle inspection. Point out that the individual doing front end work needs to be a trained technician because many times the customer's life depends on the way the job is done. Also, the equipment used for suspension and alinement repairs is costly and usually requires the services of a skilled individual. This is a well-paid area of the repair trade, and the mechanic often has the opportunity of

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	earning a bonus based on the volume of work produced. A person could also specialize and spend all his time in this field. Employment opportunities are available with new-car dealers, tire distributors, chain-store automotive service departments, and speciality shops.
	The purposes of the course are: • To permit individuals who are now working as automotive mechanics to improve and update their knowledge in the rapidly changing area of suspension and alinement service • To provide training in suspension and alinement service for students in vocational and occupational education programs as well as other interested persons
II. Overview of Course	Indicate that the course will cover all areas of suspension and alinement service including the following: • Types of suspensions and their repair • Alinement • Wheel balance • Diagnosis
	Point out that each student will learn the theory from class presentations and the text and then will have the opportunity to apply this knowledge by working on live jobs.
	Indicate also such items as the length of each session, the number of sessions, the procedures to be followed in class, the reasons for homework, and in general, the expectations for each class member.
	Emphasize that there will be quizzes throughout the course as well as a final examination. Note that following the final examination, time will be allotted for a review of the test and for answering questions about the course.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
A. Individual needs	Determine the background and needs of each student. Use this information to adapt the course content to meet as many of the individual needs as possible, keeping in mind the equipment available. Develop a card data file for each student listing address, phone number, needs, goals, training, work experience, and other pertinent information. This file will be valuable in giving individual aid during the course. Also, it will help to maintain contact with students after employment. Many times former students can provide up-to-date trade information, training aids, and placement assistance.
B. Work habits and attitudes	Discuss the importance of good work habits and show how these might aid an individual in maintaining and improving his position. Include such items as: • Sense of responsibility to employer and other employees • Appreciation of safety rules and regulations • Accuracy and speed Discuss the attitudes that employers expect to find in employees. Indicate that many times the cause of a worker's dismissal is related to his poor work habits and not to his lack of knowledge. Emphasize the importance of developing good work habits and desirable attitudes during the course. (Ref. What Employers Want; Why Young People Fail To Get and Hold Jobs)
III. Course Requirements	
A. Prerequisites	It would be advantageous for students to be knowledgeable in the following areas: • Basic mathematics • Basic science

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• Plane geometry • Basic automotive mechanics • Shop safety
B. Textbook	If a textbook is to be used, give its title, price, and source. Arrange for a group order.†
C. Notebook	Indicate that a looseleaf notebook is necessary for keeping class notes, job information, specification booklets, and other materials distributed during the course.
IV. General Safety	Review general rules of safety for the service garage employee. (Ref. B, pp. 47-49; General Safety Instructions; Safety in Your Future; Your Guide to Safety as a Service Garage Employee) Use films or transparencies that deal with safety to emphasize the importance of practicing safe work procedures when performing any type of repair work. Ask students to discuss their own experiences with accidents and have them indicate the procedures that should have been followed. Discuss the dangers of horseplay and hot rodding, and give examples of the possible consequences of each. Show the location of fire extinguishers and discuss fire control procedures. Explain the specific safety procedures for using the following: • Wheel balancers • Lifts and jacks for vehicles • Compressed air • Coil spring compressors
A. Protective clothing	State school policy relative to coveralls, shop coats, or uniforms. Mention possible storage areas for clothes and outer garments.

†Reference citations are shown on page 61.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
B. Safety glasses	Indicate the school policy relative to the wearing of approved safety glasses. Arrange for a group purchase of approved safety glasses for those who wish to have their own glasses.
V. Automotive Suspension and Steering Systems	Review briefly the development of the modern suspension and steering system, including the Ackerman steering and kingpin axle. Explain how the suspension of a vehicle tends to improve its ride and handling qualities. Define and explain with simple examples how the following terms affect the ride and handling of vehicles: • Sprung weight • Unsprung weight
A. Types of suspensions	Indicate that leaf springs were the first type of suspension used. Although leaf springs are still being used, point out that other types of suspensions have been tried and found satisfactory. Explain, illustrate, and point out some of the advantages and disadvantages of the following types of suspensions: • Leaf spring (transverse; full, semi, and quarter elliptic) • Coil spring (common) • Torsion bar (VW and Chrysler) • Air suspension (Mercedes-Benz) • Hydrolastic (Austin-American) • Hydraulic (Citroen)
B. Front suspension	Indicate how the efforts to reduce the unsprung weight of a vehicle lead to the development of the independent front suspensions. (Ref. A, p. 37).

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Explain and illustrate the following types of front suspensions: • Solid axles (trucks and older cars) • "A" frame (common) • Trailing arm (old VW) • Leading arm (Citroen 2CV) • Swing axle (Hillman Imp) • Mac Pherson (BMW) • Sliding piller (Morgan) By using the lift, compare as many different types of front suspensions as are readily available. (Ref. F, pp. 284-288)
C. Rear suspension	Indicate that the solid axle is the main type of rear suspension found on American-made cars, but many alternatives are used on foreign cars. Explain and illustrate the following types of rear suspension: • Hotchkiss drive (common) • Torque-tube drive (Buick) • Swing axle (VW) • Full independent (Corvette) • Foreign types Point out that independent rear suspension may improve roadability and ride but it means an additional first cost as well increased service costs. (Ref. A, pp. 38-46; Ref. B, pp. 458-459).
D. Suspension linkage	Indicate that much of the service to the suspension linkage involves the replacement of worn parts. Display samples and explain the operation and wear points of the following: • Ball joints • Kingpins and bushings

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• Tie rods and ends • Rubber suspension bushings • Shock absorbers Point out that even though most modern cars have extended lubrication periods, the mechanic still has to be able to follow a lube chart and perform a quality lubrication. Demonstrate how to inspect the suspension system for excessively worn component parts. Emphasize that it is the responsibility of the mechanic to inform the customer when a hazard exists. (Ref. C, pp. 62-66)
E. Shock absorbers	Explain the purpose and operation of shock absorbers. Display and explain the following types of shock absorbers: • Piston • Direct acting • Load leveler Demonstrate how to test shock absorbers on and off the car. Indicate that most original equipment shock absorbers need to be replaced after about 20,000 miles. Thus, many cars on the road today need to have their shock absorbers replaced. (Ref. A, p. 63; Ref. D, pp. 459-460)

Review Discussion

1. Explain the purpose of the independent front end suspension system.
2. Describe the difference in construction between the ball joint and the kingpin type of suspension.
3. List and explain the use of three types of suspension springs.
4. Define and explain the importance of unsprung weight.
5. Explain the damage that can be caused by defective shock absorbers.

SUSPENSION SERVICE AND REPAIR

OBJECTIVES

The student will be able:

- To inspect and service kingpins and ball joints
- To inspect and service steering linkages
- To inspect and service spring shackles and stabilizer and suspension bushings
- To remove and replace springs and adjust curb height
- To service and replace shock absorbers
- To explain the different types of shock absorbers available and recommend the best type for specific kinds of use
- To diagnose suspension problems and suggest the use of spring boosters when required
- To explain to the customer the reasons spring boosters are needed

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
I. Ball Joints	
A. Inspection	Explain and demonstrate how the location of the coil spring determines where the jack is placed when raising a vehicle to inspect the ball joints (Ref. G, pp. 31-24 — 31-25, 31-69).†
	Show how to use a wedge to support the upper A frame when inspecting Falcon type ball joints.
	Demonstrate how to test both types of front suspensions for axial and radial play. Indicate that ball joints should be replaced when the play exceeds State inspection requirements or factory specifications. (Ref. E)

†Reference citations are shown on page 61.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
B. Lubrication	Show how to lubricate ball joints. Obtain lubrication procedures from service manuals.
C. Replacement	Emphasize the importance of proper jack placement when repairing both types of front suspension.
	Caution students to use a wedge and other support tools when replacing ball joints because the tension on the spring may be several hundred pounds which could be very dangerous if not properly contained.
	Demonstrate how to use the air chisel and other special tools for the removal of ball joints. Have students refer to service manuals for specific removal procedures.
	Explain why the bolts used for installing ball joints are special high-strength bolts.
	Explain the different locking devices used to hold ball joints in place.
	Have students practice inspecting, lubricating, removing, and replacing ball joints.
II. Kingpins and Bushings	Point out that kingpins and bushings are located in the: • Spindle • Knuckle
A. Inspection	Demonstrate how to check kingpins and bushings for wear. Point out the maximum allowable movement at the wheel as specified by the State inspection requirements. (Ref. E)
	Emphasize the importance of proper jack placement when inspecting and servicing kingpins.
B. Lubrication	Show how to lubricate kingpins.
C. Replacement	Explain the various methods that are used to lock the kingpin in position.
	Point out that some vehicles have full floating kingpins and bushings with needle bearings and this type will fit without further machining.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Demonstrate different methods of removing and replacing kingpins and bushings. Have students refer to service manuals for specific removal procedures.
	Have students practice inspecting, lubricating, removing, and replacing kingpins and bushings.
	Demonstrate how to install bushings and fit kingpins by the use of reamers and hones.
	Have the students practice fitting kingpins and bushings using reamers and hones.
III. Pivot Pins and Bushings	
A. Inspection	Demonstrate how to inspect the pivot pins and bushings. Point out the wear limits that are specified by the State for pivot pins.
	Emphasize the importance of proper jack placement when inspecting and servicing pivot pins and bushings.
B. Lubrication	Show how to lubricate pivot pins. Obtain lubrication procedures from service manuals.
C. Replacement	Demonstrate the removal and replacement of pivot pins and bushings.
	Have students practice inspecting, lubricating, removing, and replacing pivot pins and bushings.
	Emphasize that when pivot pins or bushings are replaced, the front suspension *must* be alined.
IV. Springs	Explain the basic construction of the following types of springs: • Semielliptic leaf • Coil • Torsion bar • Air suspension • Hydrolastic

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	(Ref. A, pp. 53-60; Ref. F, pp. 287-288)
	Explain the common causes for spring breakage.
	Demonstrate the procedures for the removal and replacement of coil springs.
	Have students practice removing and replacing coil springs.
	Demonstrate the procedures for the removal and replacement of leaf springs.
	Explain why new bushings are always inserted between the bolt and hanger when leaf springs are replaced.
	Explain why springs should be replaced in pairs.
	Have students practice removing and replacing leaf springs.
	Demonstrate the procedures for the removal and replacement of torsion bars.
	Have students practice removing and replacing torsion bars.
V. Curb Height	Explain how to check the curb height of a vehicle by inspection and measurement. (Ref. A, p. 150)
	Point out that the manufacturer's specification of curb height is usually from a point on the vehicle such as a body molding or A frame bolt to the road surface without driver and passengers but with normal operating load.
	Explain why the curb height of a vehicle must be adjusted before the alinement is started.
	Point out the conditions that affect the curb height of a vehicle and show how to correct the following:
	• Broken or fatigued springs
	• Excessive trunk load
	• Lowering devices

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	(Ref. A, pp. 138-163)
	Demonstrate how to adjust curb height on a vehicle equipped with torsion bar suspension.
	Have students practice measuring and adjusting curb heights on vehicles equipped with torsion bars.
VI. Shock Absorbers	
A. Inspection	Show how to visually inspect shock absorbers for leaks. Indicate that any shock absorber that shows signs of leaking should be replaced.
	Point out that some noises coming from the front or rear suspension may be due to shock absorbers or their mountings.
	Demonstrate how to test shock absorbers on the car by bouncing. Note that serviceable shock absorbers should limit the movement to one rebound.
	Show how to disconnect a shock absorber from a vehicle and test its operation.
B. Replacement	Demonstrate the method of removing and replacing shock absorbers including the placement of rubber grommets. (Ref. C, pp. 224-225)
	Show how to use special tools to remove frozen fittings.
	Have students practice inspecting, removing, and replacing shock absorbers.
	Explain why it is important to know the operating conditions of the vehicle before recommending the proper type of replacement shock absorber.
	Point out that shock absorbers are available in the following types: • Heavy duty • Adjustable • Racing

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
VII. Booster Devices.	Explain why booster devices are used on vehicles. Demonstrate how to install the following types of booster devices: • Load levelers • Air lifts • Air over oil shocks • Booster springs
VIII. Steering and Suspension Linkage	Explain why various types of steering and suspension linkages are used. Explain the functions and operation of the following: • Pitman arm • Tie rods and ends • Idler arm • Drag link • Relay rod (center link) (Ref. C, pp. 62-66) Demonstrate how to inspect and service steering and suspension linkages. Refer to service manuals for specific procedures. Demonstrate how to remove bushings with a puller and also with normal hand tools. Demonstrate the removal of a tapered tie rod end by the use of a "pickle fork" or two hammers. Caution students to be sure that the suspension units are not under load when servicing component parts. Have students practice inspecting, lubricating, and servicing steering and suspension linkages.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
IX. Safety	Emphasize the importance of following safe work procedures when servicing the suspension system. Also, point out that an error made during the diagnosing or servicing of a suspension system could easily endanger the customer's life. Review court cases in which mechanics and garages have been held responsible for errors they made.

Review Discussion

1. Name two classes of kingpins and bushings used on vehicles.
2. Describe how to check the various types of ball joints for wear.
3. Explain the advantages of ball joints over kingpins and bushings.
4. Explain how to check kingpins for wear.
5. Explain where to place the jack when replacing ball joints on vehicles equipped with conventional and Falcon type suspensions.
6. Describe the function of five types of springs used on vehicles.
7. Explain how to remove and replace a front coil spring.
8. Explain how to adjust torsion bars to change vehicle curb height.
9. Explain how to test shock absorbers on and off a vehicle.
10. Discuss methods of removing frozen spring bushings, nuts, and tie rod ends.

WHEEL ALINEMENT

OBJECTIVES

The student will be able:

- To explain the basic principles of wheel alinement
- To identify and explain the function of caster, camber, toe-in, steering axis of inclination, and toe-out on turns
- To use information obtained from a customer interview to aid in the diagnosis of alinement problems
- To recognize worn or defective parts in the suspension system
- To diagnose the reasons for excessive wear in the suspension system
- To diagnose the reasons for malfunctions of the suspension system
- To check and adjust caster, camber, and toe-in
- To check and diagnose unusual suspension and alinement problems
- To modify suspension settings for unusual conditions of operation or load
- To check and adjust rear suspension alinement

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
I. Wheel Alinement Factors	Explain front end geometry and how the position of the wheels affect the steering and handling characteristics of a vehicle.
A. Camber	Define and explain camber. (Ref. A, pp. 72-73; Ref. B, pp. 478-479; Ref. C, pp. 29-34)†
	Explain how camber makes the steering easier by permitting the weight of the vehicle to be supported by the inner wheel bearing and spindle.
	Point out that camber is a directional control angle and measured in degrees.

†Reference citations are shown on page 61

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Explain and illustrate positive and negative camber. Show the effects of camber by using the illustration of steering a bicycle by leaning.
	Point out how incorrect camber may cause excessive wear of: • Ball joints • Wheel bearings • Tire edges
	Demonstrate how to obtain a camber reading using a gauge. Emphasize that the wheels should be straight ahead when a reading is taken.
	Have students practice obtaining camber readings of vehicles.
	Demonstrate the actual caster-camber adjustments later in the lesson.
B. Caster	Define and explain caster. Indicate that caster is a directional angle and has little effect on tire wear. (Ref. C, pp. 35-39)
	Illustrate the effect of caster by using a furniture caster. (Ref. A, p. 76)
	Explain and illustrate with a drawing positive and negative caster.
	Explain how caster affects the following: • Steering (hard or pull to one side) • Road shock and shimmy • Wander and weave at high speed
	Demonstrate how to obtain a caster reading using a gauge.
	Have students practice obtaining caster readings of vehicles.
C. Steering axis of inclination	Define and explain steering axis of inclination or kingpin inclination. (Ref. A, p. 73; Ref. B, p. 478)

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Illustrate with a diagram the included angle of camber and steering axis of inclination. (Ref. A, p. 73; Ref. C, pp. 40-44)
	Show the effect of the axis of steering inclination on steering by using a model or a pencil and a cardboard disk. (Ref. A, p. 74; Ref. B, pp. 479-481)
	Explain how steering axis of inclination affects the steering of a vehicle by: • Reducing the need for excessive camber • Distributing the weight of the vehicle more evenly under the road contact area of the tire • Providing a pivot about which the wheel may turn, thus producing easier steering and faster recovery from a turn (Ref. A, pp. 74, 76; Ref. B, pp. 479-481)
	Demonstrate how to check the steering axis of inclination by using a caster-camber gauge. Obtain specific settings from service manuals and charts.
	Point out this angle is nonadjustable, and if correction is necessary parts will have to be replaced.
D. Toe-in	Define and explain toe-in.
	Explain the relationship of toe-in to camber and caster.
	Explain and show how toe-in affects tire wear. (Ref. B, p. 501; Ref. F, p. 311)
	Indicate that toe-in is the final adjustment in a wheel alinement.
E. Toe-out on turns	Explain toe-out on turns and how it affects the handling of a vehicle. (Ref. B, p. 482)
	Show how the steering arms control toe-out on turns, and point out that normally no

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	adjustment is possible. (Ref. A, p. 78; Ref. B, p. 482) Explain how toe-out on turns causes tires to: • Scuff • Squeal Show how "slip angles" affect tire wear as the speed of a vehicle increases. (Ref. F, pp. 311-312) Demonstrate how to check toe-out on turns using turning plates. Obtain specific settings from service manuals. Note that if the readings are not within allowable limits the steering arms have to be replaced. Have students practice checking toe-out on turns on a variety of vehicles.
F. Rear wheel geometry	Explain how the rear wheel geometry affects the handling of the vehicle. Indicate that on most cars the rear axle and rear suspension systems are designed so they assist in steering the vehicle around a corner. The point about which a vehicle turns changes due to the deflection of the springs.
II. Wheel Alinement Preparation	
A. Customer interview	Point out the importance of and reasons for obtaining from the customer the following information: • Type of driving conditions (roads and speed) • Type of loads carried in vehicle • Amount of fuel usually kept in tank • Handling of vehicle • Tire wear Explain how the above conditions can be compensated for by changes in alinement settings.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
B. Inspection of vehicle	Indicate why the front tires must be in good condition and have the same diameter for a satisfactory wheel alinement. Equalize all tire pressures to manufacturer's specifications. (Ref. A, p. 165)
	Explain why it is necessary to check the curb height of a vehicle before performing a wheel alinement.
	Review how to check the curb height of a vehicle.
	Indicate that any abnormal sagging condition must be repaired unless it is caused by a normal load.
	Review why it is necessary to check the front suspension and steering linkage of the vehicle before performing a wheel alinement.
	Explain why it is important to check wheel runout when using equipment that contacts the rim or tire.
C. Condition of work area	Explain why work area and equipment must be level during the alinement process.
	Show how to check and level the alinement equipment.
D. Positioning of vehicle	Show how to adjust ramps or turn plates to the tread of a vehicle.
	Demonstrate how to position a vehicle when plates are used.
	Demonstrate how to position the vehicle when portable stands are used.
III. Wheel Alinement Procedures	Indicate that specific procedures and specifications for wheel alinements may be obtained from service manuals and charts.
	Show how to read and write the specifications on a work order.
A. Camber-caster	Point out that most camber-caster adjustments on American-made cars and light trucks are made by using:

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• Eccentrics • Shims • Slotted holes • Serrated upper control arm shaft • Adjustable rod and eccentric bushing (Ref. G, p. 30-5; Snap-on teaching aid)
	Demonstrate how to adjust camber and caster on different types of suspensions. Show the use of special tools where required.
	Have students practice making camber-caster adjustments on different types of suspensions. Students should acquire the proficiency necessary for an entry mechanic.
B. Toe-in	Demonstrate how to make toe-in adjustments on different types of suspensions. Explain the various kinds of equipment used to measure toe-in. Emphasize that toe-in is measured in inches and not in degrees.
	Explain how toe-in adjustments affect the straight ahead position of the steering wheel.
	Have students complete their alinement work by making toe-in adjustments.
C. Final check	Caution students to check carefully all locking devices at the conclusion of every wheel alinement.
	Emphasize that the final step in an alinement is to road test the vehicle to be sure the: • Front end tracks properly • Steering wheel is centered • Steering is functioning properly • Front end has no unusual noise

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Indicate that on delivery to the customer the inside and outside of the vehicle should be free of dirt and grease.
IV. Diagnosis of Unusual Suspension and Alinement Problems	Point out that to properly diagnose unusual suspension and alinement problems, the mechanic needs to have knowledge and experience of other areas of the automobile because some problems that appear to be related to suspension or alinement are really the result of other factors.
A. Additional customer information	Explain how additional information from the customer might be helpful in the diagnosis of unusual suspension and alinement problems.
	Develop with the students a list of items which would help a mechanic gather useful information from the customer. Consider such items as: • Nature of problem • Duration of problem • Previous repairs to suspension system • Time or mileage since last service to suspension system • Other problems of vehicle • Types and frequency of loads carried
	Have students role play several situations involving an interview between a mechanic and a customer. Have students evaluate the information gathered during each interview and suggest ways to improve the communication between mechanic and customer.
B. Road test	Explain how a road test of the vehicle may substantiate the customer's complaints and indicate the need for other services related to: • Tires • Brakes • Ignition and lights

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• Fuel • Drive train
	Have students road test cars and note unusual alinement problems.
C. Visual inspection	
1. Tire wear	Use visual aids and actual tires to show how tire wear may indicate: • Alinement problems • Balance problems • Poor driving habits • Improper inflation
2. Curb height	Show how the curb height of a vehicle may indicate abnormal loading conditions which would affect the caster and camber settings.
3. Tracking	Show how poor tracking of a vehicle may indicate a: • Broken spring center bolt • Bent frame • Damaged or improperly adjusted control arm
4. Application	Have students practice checking vehicles with unusual suspension and alinement problems.

Review Discussion

1. Discuss the necessary services that must be done before a vehicle can be alined.
2. Explain how to check the levelness of the area used for wheel alinement.
3. Describe how to properly position a vehicle for alinement.
4. What must be known by the mechanic before curb heights can be adjusted?

5. What vehicle operating conditions must be considered in order to perform a satisfactory alinement?

6. Explain how to adjust camber and caster on ball joint and the kingpin types of suspensions.

7. Explain how tire type and condition affect wheel alinement.

8. Explain the situations when a mechanic would not adjust the front end according to factory specifications.

9. Which direction from the vertical is negative caster?

10. Which direction from the vertical is positive camber?

11. Define steering axis of inclination and explain how it affects the steering of a vehicle.

12. Describe the effects of incorrect camber and caster settings on vehicle performance.

13. Can toe-out on turns be adjusted?

14. How does incorrect toe-in or toe-out affect tire wear?

15. Describe some of the causes of excessive tire wear.

16. Explain the terms oversteer and understeer.

17. Discuss the suspension and alinement problems that can be diagnosed directly by a road test.

18. Explain how the customer's loading or use of his vehicle affects alinement and tire wear.

19. Discuss some diplomatic ways of explaining to a customer that many of his car problems relate to his own poor driving habits.

20. What parts of the car are factory balanced?

WHEEL BALANCE

OBJECTIVES

The student will be able:

- To diagnose wheel balance problems
- To check wheel runout
- To static balance wheels
- To dynamic balance wheels (on and off car)

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
I. Importance of Wheel Balance	Discuss the advantages of having the wheels of a vehicle balanced.
A. Steering stability	Explain how improper wheel balance causes "wheel tramp" and "wheel shimmy." (Ref. A, pp. 166-167; Ref. C, pp. 50-51)†
B. Tire life	Explain and illustrate how improper wheel balance shortens tire life. (Ref. B, p. 501)
C. Wear and vibration	Explain how an unbalanced wheel vibrates the entire body and chassis and causes wear of the suspension parts.
II. Wheel and Rim Runout	Explain how radial and lateral runout affect wheel balancing.
	Show how to check for radial runout. Indicate that wheels exceeding .060 of an inch runout should be replaced. (Ref. G, p. 30-24)
	Demonstrate how to check for lateral runout. Indicate that wheels exceeding .090 of an inch runout should be straightened or replaced. (Ref. G, p. 30-24)
	Have students practice checking radial and lateral wheel runout.
III. Tire Condition	Explain how different types of tire wear affect balance.

†Reference citations are shown on page 61.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Indicate that tires should run true for an accurate job of balancing. Note that tire runout is not as critical as wheel runout, because a tire casing is flexible and changes shape with speed. If the runout exceeds one-eighth of an inch, the tire must be trued or replaced. (Ref. D, p. 445)
IV. Static Balance	Explain static balance. Indicate that a wheel in balance has its weight equally distributed around the axis of rotation. Static balancing is done with the wheel assembly at rest.
	Indicate that most wheels and tires are out of balance. Illustrate this by loosening the wheel bearings a little and releasing the brakes and note that the heavy part of the wheel settles to the bottom. (Ref. A, p. 169)
	Explain why all old weights and stones need to be removed from a tire before starting any balancing.
	Discuss the range, types, and sizes of weights that are available for wheel balancing.
	Demonstrate static balancing of a tire and wheel assembly by the use of a bubble balancer. Point out that the bubble balancer only balances the wheel and tire and does not include the hub and brake drum or disc.
	Explain why the weights should be split or halved on the installation to compensate for dynamic balance.
	Have students practice static balancing of tire and wheel assemblies.
V. Dynamic balance	Explain dynamic balance. Indicate that dynamic balancing is done while the wheel assembly is in motion.
	Show with a sketch why a tire that is statically balanced may not be dynamically balanced. (Ref. F, p. 303)

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Point out that some types of dynamic balancers will balance a wheel in two planes.
	Indicate that any loose material inside the tire makes it impossible to balance the tire correctly.
	Point out the hazards associated with dynamic wheel balancing such as: • Flying stones • Moving parts
A. On the car	Describe and illustrate the different types of on-the-car dynamic wheel balancers that are available.
	Demonstrate on-the-car dynamic wheel balancing. (Ref. A, pp. 171-172)
	Point out that the main advantage of on-the-car dynamic wheel balancers is their ability to balance the wheel, hub, and brake drum or disc as a unit. Note that cars equipped with disc brakes require a more powerful spinner than cars equipped with drum brakes.
	Consider inviting manufacturers' representatives to demonstrate equipment not available or arrange trips to commercial tire shops to observe a variety of equipment in use.
	Have students practice on-the-car dynamic balancing of wheels.
B. Off the car	Describe and illustrate the different types of off-the-car dynamic wheel balancers that are available.
	Demonstrate off-the-car dynamic wheel balancing.
	Have students practice off-the-car dynamic balancing of wheels.
VI. Rear wheel balancing	Demonstrate how to balance rear wheels. Include the jacking procedures for both regular and limited slip types of rear axles. (Ref. G, p. 30-25)
	Have students practice balancing rear wheels.

Review Discussion

1. Describe some of the conditions caused by poor wheel balance.
2. What is static balance?
3. What is dynamic balance?
4. How can dynamic unbalance be corrected.
5. What are the various methods used to balance wheels?
6. Explain how to balance rear wheels.
7. What are some customer's complaints that indicate the need of wheel balancing?
8. What precautions should be observed when balancing the rear wheels of a vehicle?
9. What are the advantages of balancing the tire, wheel, hub, and brake drum or disc as an assembly?
10. How would you attach wheel weights when balancing a "Mag" wheel?
11. When balancing wheels on the car, explain why a more powerful spinner is required for vehicles equipped with disc brakes than for vehicles equipped with drum brakes.
12. Explain why an out-of-round tire that has been properly balanced may continue to cause vibrations.
13. Discuss methods used to make a tire run true.
14. Discuss methods of testing such rotating parts as the flywheel, driveshaft, and engine to determine whether or not they are out of balance.
15. Discuss the ability of different types of spinner wheel balancers to balance wheels and tires in two planes.

MANUAL AND POWER STEERING

OBJECTIVES

The student will be able:

- To inspect steering gears and recognize leaks and excessive play and wear
- To adjust steering gear end play and mesh
- To remove, overhaul, and replace different types of steering gear assemblies
- To remove and replace energy absorbing steering gears
- To service power steering hoses and belts
- To test and adjust power steering systems
- To overhaul component parts of the power steering system

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
I. Steering Systems	Describe and illustrate different types of steering systems including: • Worm and sector • Cam and lever • Worm and roller • Recirculating ball (compacts) • Rack and pinion (sports and light sedans) • Power steering (Ref. A, pp. 200-211)†
II. Manual Steering	
A. Adjustment	Demonstrate how to perform the following checks and adjustments on steering gears:

†Reference citations are shown on page 61.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• Play in the straight ahead position • End play or preload in bearing • Mesh or backlash Refer to service manuals for specific specifications and procedures. Indicate there should be no play in the straight ahead position. Explain how it is possible to incorrectly adjust a steering box too tight which would prevent the wheel returning to the straight ahead position. Have the students practice making bearing end-play and steering mesh adjustments on a variety of shop units. Later, have students check and adjust the steering gear boxes on their own vehicles.
B. Removal and Replacement	Demonstrate the procedures for the removal and replacement of a manual steering assembly. Include the following: • Use fender and seat covers to prevent damage to the vehicle • Use a puller when removing the pitman arm and steering gear to prevent damage to the threads • Note the color and position of wires before removing the steering column • Note position of alinement shims and mark verticle position of column to facilitate reinstallation
C. Overhaul	Point out that the steering system is subjected to the following types of damage: • Wear • Accident (bent and broken) • Lack of lubrication

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Demonstrate how to overhaul a steering gear.
	Explain how to prevent damage to the ball guides by not allowing the ball nut on a recirculating ball steering gear to travel to the extreme ends of the worm.
	Show how to center the sector shaft.
	Have students practice overhauling and adjusting various types of manual steering gears. Refer to service manuals for specifications and procedures.
III. Power Steering	Explain the functions and operation of a power steering unit. (Ref. C, pp. 72-74)
A. Types -	Indicate that the commonly used power steering units include: • Linkage • Integral
	Discuss the advantages and disadvantages of the linkage type power steering including the following items: • Easy installation and removal • Lower cost • Less road feel • Exposed location (Ref. C, pp. 123-128)
	Discuss the advantages and disadvantages of the integral type power steering including the following items: • Compact installation • Better road feel • Difficult to service • Impractical to install in the field (Ref. C, pp. 104-121)

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
B. Minor service	Show how to perform the following minor services: • Add fluid • Adjust belt tension • Change belt • Tighten fittings • Remove and replace hoses Explain why it is important to have the belt in good condition and at the proper tension. Point out that a worn belt or too much tension may lead to power steering pump failure and damage to the alternator or water pump bearings.
C. Adjustments	Demonstrate how to make the following adjustments: • End play or preload in worm bearing • Mesh • Centering of spool valve Explain how to prevent damage to the bearings by using a spring scale or torque wrench when adjusting preload.
D. Pump service	Explain the operation of the power steering pump, including the following types: • Slipper • Roller (Ref. C, pp. 88-103) Demonstrate how to service the following pump components: • Seals • Bearings • Pump mechanism

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Refer to service manuals for specific repair procedures.
	Explain why it is important to maintain clean work procedures when servicing a power steering pump.
	Demonstrate how to perform a pressure test of a power steering pump by using special tools and gauges. (Ref. D, p. 490)
E. Control valves	Show samples and explain the operation of the following types of power steering control valves including: • Linkage • Torsion bar • Rotary
	Demonstrate how to center the control valve.
F. Steering gears	Demonstrate the overhaul of commonly used power steering gear units.
	Have students practice overhauling various models of power steering units produced by major manufacturers.
	Emphasize the importance of performing quality work because a mechanic's error could cost the customer his life.

Review Discussion

1. Describe the various types of manual steering gears and adjustment procedures.
2. Explain what happens if a steering box is adjusted too tight.
3. How is a steering gear checked for adjustment?
4. What is the major advantage of rack and pinion steering?
5. What is the advantage of variable ratio power steering?
6. How are pump shaft seals protected when a power steering pump is rebuilt?
7. Why is cleanliness so important during the rebuilding of a power steering pump?

SAMPLE FINAL EXAMINATION

Sample Final Examination Part I — Fill-In Statements

Directions: For each statement, write the word or phrase that, when inserted in the blank, will complete the statement correctly.

1. Oil pressure for the power steering system is produced by the POWER STEERING PUMP.

2. A vibration in a vehicle that tends to occur at a specific road speed is usually caused by IMPROPER WHEEL BALANCE.

3. Toe-out on turns is usually referred to as STEERING GEOMETRY.

4. According to State inspection rules, the maximum allowable movement in a kingpin type front suspension is ONE-QUARTER OF AN INCH at the wheel.

5. On the Falcon type ball joint suspension, the springs are attached to the UPPER CONTROL ARMS.

6. A free-turning wheel that always comes to rest at the same spot is usually OUT OF BALANCE.

7. When a car rounds a corner at high speed, the difference between the actual path and the path the wheels are pointing is called the SLIP angle.

8. The front springs used on Chrysler products are called TORSION BARS.

9. Shock absorbers may be tested on the vehicle by BOUNCING.

10. On a conventional type of independent suspension, the springs are placed between the UPPER AND LOWER CONTROL ARMS.

11. On a vehicle equipped with torsion bars, the curb height of the vehicle may be changed by TURNING A BOLT.

12. The most popular type of shock absorber in use at the present time is the DIRECT ACTING type.

13. Two alinement factors that influence tire wear are TOE-IN and CAMBER.

14. The part of the spring that wraps around the spring shackle is called the SPRING EYE.

15. Toe-in can be adjusted by changing the length of the TIE-ROD.

16. An under inflated right front tire will cause the vehicle to pull to the RIGHT.

17. The inflation pressure of tires should be checked when the tires are COLD.

18. Two types of wheel balance are STATIC and DYNAMIC.

19. As the speed of a wheel increases, problems due to unbalance become MORE NOTICEABLE.

20. Toe-in is required because the front wheels of a vehicle in motion have a tendency to TOE-OUT.

21. In a typical front suspension system, the upper suspension arm is connected between the frame and the STEERING KNUCKLE.

22. When a wheel of a coil spring suspension system is deflected by passing over a bump, the spring is COMPRESSED.

23. When a direct-acting shock absorber rebounds, fluid flows out of the upper part of the cylinder and also the RESERVOIR.

24. When the point of intersection of a front suspension is below the surface of the road, the front wheel will tend to TOE-OUT.

25. Toe-out on turns means that the inner wheel of a vehicle negotiating a corner will turn in a(an) SMALLER arc than the outer wheel.

26. The device that allows a leaf spring to change its length as it flexes is called a(an) SHACKLE.

27. Ball joints should be checked periodically for AXIAL and RADIAL wear.

28. The steering axis of inclination may be changed by the REPLACEMENT OF PARTS.

29. Incorrect camber may cause excessive wear of the wheel bearings, BALL JOINTS, and TIRE EDGES.

30. The last step in a wheel alinement job is ROADTESTING THE VEHICLE.

Sample Final Examination Part II — Multiple Choice

Directions: For each statement, place in the space to the left of the question the letter of the choice that completes the statement most accurately.

C 1. The tilt of the top of the wheel in or out is called

A. caster
B. toe-in
C. camber
D. steering axis inclination

D 2. When viewed from the front, the inward tilt of the top of the steering knuckle support is called

A. caster
B. toe-out
C. camber
D. steering axis inclination

B 3. When the front of the wheels is closer together than the back of the wheels, it is called

A. toe-out
B. toe-in
C. toe-out on turns
D. toe-in on turns

C 4. More positive caster is obtained by moving the top ball joint or the top of the kingpin

A. in toward the frame of the car
B. out away from the frame of the car
C. to the rear of the car
D. to the front of the car

D 5. The amount of toe-in required in a vehicle is determined by the

A. wheel base
B. camber
C. toe-out on turns
D. forward motion of the vehicle

B 6. Too much positive caster will cause

A. excessive tire wear
B. slow speed shimmy
C. high speed vibration
D. excessive wear to ball joints

A 7. Toe-out on turns is controlled by the

A. length and angle of the steering arms
B. length of the tie rods
C. size of the tires and wheels
D. speed of the vehicle as it goes around a corner

C 8. Too much negative caster will cause

A. excessive tire wear
B. high speed vibration
C. wandering
D. excessive wear to wheel bearing

C 9. When checking caster, the front wheels must be

A. in straight ahead position
B. turned a total of 20°
C. turned a total of 40°
D. turned as far as possible

B 10. The type of oil generally used in power steering units is

A. 10-30 engine oil
B. automatic transmission type A
C. brake fluid
D. EP-90

A 11. When adjusting any integral power steering gear, it is most important that the steering linkage be disconnected from the

A. pitman arm
B. steering wheel
C. front wheels
D. drive shaft

D 12. The gauge used to check the fluid pressure in any power steering system must have a maximum range of

A. 100 p.s.i.
B. 300 p.s.i.
C. 500 p.s.i.
D. 2000 p.s.i.

C 13. When there is no oil pressure in a power steering system, the most likely cause is

A. low tire pressure
B. improper wheel alignment
C. stuck relief valve
D. rough pump bearings

C 14. Spool valves in hydraulic steering systems are initially controlled by

A. fluid
B. air pressure
C. the driver
D. the wheel spindle

A 15. If a power steering gear tries to steer itself, the

A. spool valve is incorrectly positioned
B. idle speed is set too high
C. steering linkage needs adjustment
D. bearing preload is too heavy

A 16. The steering valve must be so positioned that is provides

A. equal torque in both directions.
B. a quick recovery on turns
C. 30 ft. lbs. torque
D. straight tracking

C 17. When reassembling a power steering unit, generally the old "O" rings and seals should be

A. washed carefully and reused if not damaged
B. lubricated and reused
C. discarded and replaced with new ones
D. kept submerged in fluid until used

B 18. To adjust the centering of the spool valve, the steering gear must be

A. installed in the car
B. connected to the steering gear pump
C. disconnected from the steering gear pump
D. disconnected from the pitman arm

C 19. If the centering of the spool valve is incorrect, it can be adjusted by

A. changing the oil pressure
B. adding or removing shims
C. turning the spool valve adjuster
D. changing the position of the steering wheel

B 20. If a power steering pump belt squeaks when the steering wheel is turned to the stops, usually it indicates that the

A. belt is too tight
B. belt is too loose or worn
C. cross section of the belt is incorrect
D. fluid is low

C 21. If a linkage type power steering cylinder is damaged internally, it must

A. be disassembled for adjustment
B. have the internal parts replaced
C. be replaced as a unit
D. be honed and fitted with an oversize piston

A 22. The weight or pressure required to deflect a spring leaf is called the

A. spring rate
B. spring weight
C. spring deflection
D. spring rebound

C 23. The rear suspension system in which the driving torque is absorbed by the springs is called a

A. torque-tube drive
B. differential drive
C. Hotchkiss drive
D. Hooke's drive

C 24. The rear suspension system in which the driving torque is transmitted to the engine mounts by connecting the differential housing to the transmission housing is called a

A. Hooke's drive
B. Hotchkiss drive
C. torque-tube drive
D. differential drive

B 25. In a rear suspension system that uses coil springs, the devices connected between the housing and the frame are called

A. axle arms
B. control arms
C. stabilizers
D. wheely bars

C 26. In a typical ball joint type front-suspension system, the lower suspension arm is connected between the car frame and the

A. upper suspension arm
B. shock absorber arm
C. steering knuckle
D. steering arm

B 27. When a direct-acting shock absorber is compressed or telescoped, fluid passes through the piston orifices into the upper part of the cylinder and

A. out of the reservoir
B. into the reservoir
C. into the dust shield
D. out of the dust shield

C 28. The point at which the centerline of the wheel and the centerline of the ball joints cross is called the

A. included angle
B. point of departure
C. point of intersection
D. slip angle

A 29. The back tilt of the steering axis from the verticle is called

A. positive caster
B. negative caster
C. positive camber
D. negative camber

A 30. Positive caster will tend to cause a vehicle to

A. rollout on turns
B. bank on turns
C. roll-in on turns
D. toe-in on turns

A 31. In the steering gear, a gear, sector, stud, or toothed roller is meshed with a

A. worm gear
B. ball bearing
C. roller bearing
D. steering wheel

C 32. The independent front suspension

A. uses fewer moving parts than a rigid axle suspension
B. uses a beam to hold the wheels together
C. allows one wheel to move up and down without directly affecting the other one
D. uses the Reverse Elliot type axle

A 33. A suspension stabilizer bar twists when

A. one spring deflects
B. the vehicle is heavily loaded
C. the vehicle is stopped quickly
D. both wheels move up and down together

D 34. The ends of the front stabilizer bar attach to the

A. upper control arms
B. frame
C. steering arms
D. lower control arms

B 35. On most vehicles that use a unit body, the shock absorbers are usually found between the

A. upper and lower control arms
B. body and upper control arm
C. lower control arm and frame
D. steering knuckle support and lower control arm

D 36. The device in the front suspension which limits the difference in spring action is called the

A. shock absorber
B. lower control arm
C. upper control arm
D. stabilizer bar

B 37. The spring eye is formed on the

A. hanger
B. main leaf
C. shackle
D. shortest leaf

C 38. The spring is attached to one end of the frame by a hanger and to the other end by a

A. clamp
B. bolt
C. shackle
D. "U" bolt

A 39. The most common type of spring used on American-made cars with independent front suspension is the

A. coil
B. leaf
C. torsion bar
D. hydraulic

B 40. The most commonly used type of leaf spring is the

A. quarter elliptic
B. semielliptic
C. three-quarter elliptic
D. full elliptic

C 41. The unsprung weight is that part of the vehicle which is

A. supported by the springs
B. not attached to the springs
C. not supported by the springs
D. directly above the springs

C 42. The purpose of a shock absorber is to

A. support the weight of the vehicle
B. increase the flexibility of the spring
C. dampen spring oscillations
D. absorb engine vibrations

B 43. The actual amount of toe-in is normally set at

A. zero inches
B. a fraction of an inch
C. 1"
D. 1 1/2"

C 44. When the outside wheel is moved about 20° during a turn, the inside wheel is moved about

A. 17°
B. 20°
C. 23°
D. 29°

D 45. When a vehicle is in motion, the parallel rolling of the front wheels is controlled by

A. caster
B. camber
C. steering geometry
D. toe-in

D 46. The rubber impregnated fabric material of a tire is called the

A. shoulder
B. tread
C. body
D. body ply

A 47. Excessive wear at the center of a tire tread is caused by

A. over inflation
B. under inflation
C. too much positive camber
D. too much toe-in

C 48. A tire tread wear that produces feather edges is caused by

A. worn brakes
B. excessive kingpin inclination
C. incorrect toe-in
D. under inflation

C 49. The pull on a vehicle caused by a road crown is best corrected by

A. running the left tire with less pressure
B. putting a larger tire on the right front wheel
C. increasing the positive caster in the left front wheel
D. increasing the amount of toe-in

D 50. The tire stem of a free turning balanced wheel will always stop at

A. the top
B. the bottom
C. the side
D. a different spot each time

B 51. Before alining the front wheels of a vehicle, the mechanic should check tire inflation, wheel bearing condition, and

A. wheel run-in
B. wheel balance
C. steering axis runout
D. toe-in on turns

B 52. Steering gear end play or preload adjustment is usually checked by using

A. a feeler gauge
B. a torque wrench
C. a dial indicator
D. prussian blue

C 53. When overhauling a power steering unit, the most important procedure that a mechanic should follow is to

A. work fast
B. paint the exterior of the unit
C. keep parts and work area free of dirt
D. use labor saving tools

D 54. When replacing a ball joint, it is very important to

A. remove the cotter pin from the stud nut
B. remove the tie-rod end
C. remove the steering knuckle assembly
D. keep the coil spring compressed

D 55. Toe-out on turns is adjusted by

A. altering the length of the tie rod
B. altering the length of the steering arm
C. altering the length of the A frame
D. replacing the damaged parts

B 56. Independent rear suspension normally has a camber adjustment and in many cases also an adjustment for

A. caster
B. toe-in
C. toe-out on turns
D. steering axis of inclination

B 57. Hard steering may be caused by

A. worn ball joints
B. lack of lubrication in the steering linkage and ball joints or kingpins
C. tight wheel bearings
D. poorly adjusted brakes

D 58. Shims are used on some front suspension systems to change the

A. kingpin adjustment
B. length of the tie rod
C. amount of toe-out on turns
D. caster adjustment

D 59. When doing a wheel alinement job, toe-in is the

A. only angle to adjust
B. first angle to adjust
C. second angle to adjust
D. last angle to adjust

B 60. When checking the ball joints on a suspension system with coil springs on the upper control arms, the jack is placed under the

A. coil spring
B. lower control arm inner shaft
C. lower ball joint
D. lower control arm and as close to the wheel as possible

Sample Final Examination Part III — Matching

Directions: In the space provided to the left of each item in Column I, write the letter of the word or phrase from Column II which best matches the item in Column I.

Column I	Column II
L 1. Excessive toe-in	A. Type of spring
M 2. Balance	B. Slip angle
J 3. Excessive caster	C. Causes tire to wear on outer edges
H 4. Axis of inclination	D. Causes tire to wear on one side of tread
O 5. Rack and pinion	E. Controls oscillation
D 6. Excessive camber	F. Pitman arm
E 7. Shock absorber	G. Toe-out on turns
C 8. Under inflation	H. Makes steering easier
A 9. Torsion bar	I. Drag link
G 10. Steering geometry	J. Hard steering
	K. Control angle
	L. Causes tire to scuff
	M. Wheel tramp
	N. Kingpin bushing
	O. Direct steering
	P. Upper control arms

USING AUDIOVISUAL MATERIALS

Audiovisual materials are both a tool for teaching and an avenue for learning and are well suited to stimulate a high level of class involvement. It is suggested that audiovisual materials be used with a variety of learning activities and that the instructor not devote an entire class session to the use of such materials. The following suggestions may help the instructor use audiovisual materials more effectively in class presentations.

Plan the Presentation (Organization and Methods)

Always preview any audiovisual material to become familiar with its content and see that it correlates with the lesson. Adult students dislike *time fillers* and inappropriate presentations. While previewing, prepare comments which might answer such questions as the following:

- What is being illustrated?
- Why is the presented material important?
- What are the important terms and understandings being presented?
- What are some appropriate topics which could be used to stimulate class discussions?

Prepare the Equipment and Materials

Request the required equipment several days ahead of time from the director of adult education or person in charge of audiovisual equipment. Then, see that it is delivered prior to the starting of the class. Check the equipment to see that it is all in working order. Before the class begins, practice using the equipment to become acquainted with its operation. Arrange the room so that everyone can see and is comfortable. Have a screen ready and place it so that the least amount of outside light is reflected onto it. The wall may be used, but a screen is much more desirable. The larger the room and the larger the audience, the larger the screen that is needed. Be sure there is a table for the projector, an electrical outlet, an extension cord, and a spare projector lamp in case the one in use fails.

If the class is held during the day, be sure the room can be darkened and ventilated. Check to see that the lights can be turned off without shutting off the power to the projector. At the conclusion of the presentation, allow the fan on the machine to cool the equipment for a few minutes before completely shutting off the power.

Orient the Class (Background Material)

Explain the subject matter that is going to be presented. Discuss the important terms used, and indicate the main points that will be covered.

Make the Presentation

Have the film threaded and the projector ready for use. Stop the film or filmstrip for discussion as the need arises during the showing instead of waiting until the presentation has been completed. A filmstrip may be used as a whole or as a part, whichever is appropriate to the needs of the trainees. It may also be stopped at any frame for discussion or questions. At the end of the showing, make your comments and encourage discussion and questions from the trainees.

Summarize the Concepts and Understandings

Itemize the important learnings on the chalkboard as they are contributed by the class. Allow time for the trainees to raise other questions which may lead to a more complete understanding of the topic. Encourage trainees to keep some kind of notation for future review.

Evaluate the Knowledges Acquired

Prepare a list of questions which might assist trainees to evaluate how well they have learned the important points of the presentation. One approach might be for the instructor to present the question and pause for a few moments to allow the trainees to form their answers before responding. Interest could be generated by asking the trainees to keep track of the number of their correct answers.

Followup With Opportunities To Explore New Knowledges

Introduce several new topics for discussion which will motivate the trainees to a further investigation of the subject.

Return the Equipment and Materials

After the class is over, make arrangements to return the equipment and school-owned audiovisual materials. For an item ordered from an out-of-school source, complete the required attendance report, prepare the material for mailing, and make arrangements for its prompt return.

PREPARING AND USING TRANSPARENCIES

Materials for use on the overhead projector may be prepared by hand, the heat-transfer process, and the color-lift process. Each method is described briefly for those who might wish to make their own original transparencies.

General Suggestions

- Select any content that is appropriate for an overhead transparency.
- Keep content of transparency simple.
- Organize the content of the transparency carefully.
- Use multiple overlays (one transparency over another) for the development of a concept or to show steps.
- Keep master and overlays in register with crosshair marks in opposite corners.
- Use color to make the transparency attractive, but only enough color for emphasis. Color-toned sheets or colored ink may be used to identify parts of a drawing or picture.
- Plan transparency for horizontal projection.
- Use letters and symbols that are at least $\frac{1}{4}$-inch high. Use a lettering guide or dry-transfer letters and symbols to produce attractive titles or labels.
- Leave a $\frac{3}{4}$-inch clear margin on all sides of the transparency.
- Use a pointer to identify a specific part and then remove it quickly or lay pointer on transparency, for a hand-held pointer cannot be kept steady and is distracting.
- Use a sliding or hinged mask to control the rate of disclosure when more than one step is included on a transparency.

Handmade Process

Produces a simple and inexpensive transparency.

Materials Needed

- Plastic sheet or roll - clear or frosted

- Markers - grease pencil or pen
- Ink - transparent or india

Suggested Procedures

- Mark directly on the plastic sheet. This may be done in front of the class as the lesson is being given or may be prepared ahead of time.
- Remove materials placed on a handmade transparency with a sponge or cloth moistened with water or a special cleaning fluid. Then the transparency is ready to be used again.

Heat-Transfer Process

Produces a transparency from almost any original that is flexible and no thicker than a sheet of paper.

Materials Needed

- Plastic sheets
- Item to be copied
- Copying machine

Suggested Procedures

- Material to be copied can be opaque or translucent but should have a carbon-type ink base *(black)*.
- Follow the directions for the specific copying machine; use the recommended type of plastic sheets.

Color-Lift Process — Drymount Press

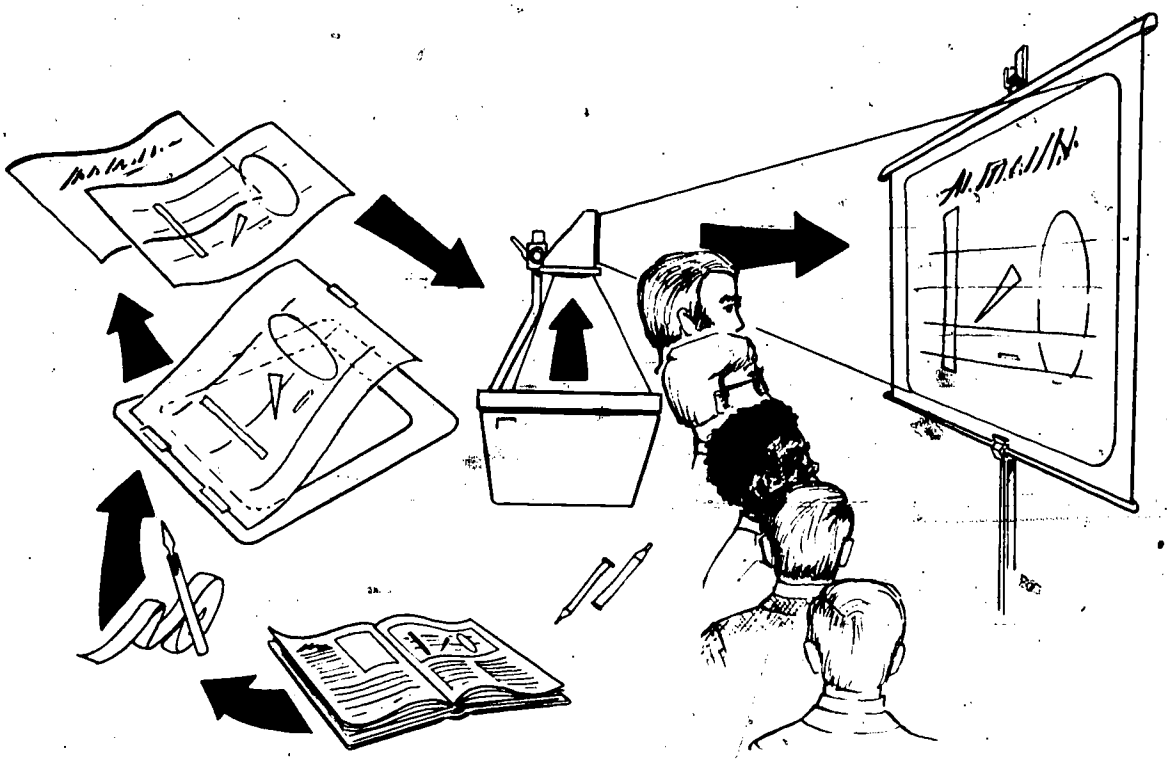
Produces a transparency by transferring the ink of a printed picture to a sheet of transparent film. Only material printed on a clay-based paper may be used.

Materials Needed

- Special film
- Detergent
- Flat tray
- Drymount press
- Pressure boards
- Item to be transferred

Suggested Procedures

- Select and test the picture to be lifted. Wet the fingertip and rub over an unprinted portion of the page. Clay-based papers will leave a white residue on fingertip.
- Dry the picture for 5 seconds in a drymount press at 270° F.
- Put the picture on the coated side of the special film and place between pressure boards. Heat the resulting sandwich for 2-3 minutes in a drymount press set for 270° F.
- Place picture and film in lukewarm water containing a liquid detergent. Soak for 2 minutes or until the paper pulls easily from the acetate.
- Wash clay coating from picture and dry film carefully.
- Spray ink surface with clear lacquer spray. Allow spray to dry; then mount transparency.



GLOSSARY

Ackerman principle: A design which reduces tire scuff during turns by making the inner wheel turn at a sharper angle than the outer wheel.

Air spring: A device that uses air under pressure to produce a spring action.

Alinement: The process of bringing the various parts of a unit into proper positions relative to each other or to a predetermined location.

Antifriction bearing: A bearing that uses rolling action (balls or rollers) to reduce friction between parts.

Automatic level control: A type of suspension system which keeps the rear of the vehicle at a predetermined level regardless of the load.

Ball bearing (antifriction): A bearing consisting of a series of hardened steel balls contained in hardened steel races.

Ball joint: A flexible joint that uses a ball and socket type of construction.

Belted-bias tire: A type of tire construction that reinforces the normal plies with a fabric or fiber glass belt which goes around the circumference of the tire just under the tread.

Bias-ply tire: A type of tire construction in which the plies crisscross each other; the common tire style.

Bushing (friction): A bearing or removable sleeve that has a bearing surface on its inside surface.

Camber: The moving of the top of the tire away from the vertical plane; when the movement is outward at the top, the camber is positive.

Casing: The part of a tire that is made of fabric or cord and to which rubber is vulcanized.

Caster (wheel alinement): The backward or forward tilt of the steering knuckle to obtain directional stability.

Center of gravity: The point of an object where all of its weight may considered to be concentrated.

Center steering linkage: A type of steering system that uses tie rods connected to steering arms and a central idler arm.

Chassis: The frame, suspension, and running gear of a vehicle without the body and fenders.

Coil spring: A spring steel rod wound in a spiral pattern.

Contact patch: The part of the tire tread that contacts the road surface.

Cornering wear: Tire-tread wear caused by taking turns at excessive speeds.

Direct-acting shock absorber: A device that uses a double acting piston moving in a cylinder to restrict spring movement.

Directional stability (steering): The ability of a vehicle to move forward in a straight line with a mimimum of driver control.

Drag link: A steel rod that connects the pitman arm to one of the steering knuckles or a center idler arm.

Dropped axle: A front axle that has been changed so as to lower the frame of the vehicle.

Dynamic balance: The even distribution of the weight mass of a revolving object.

Eccentric (off center): A protrusion on a shaft that rubs against or is connected to another part in order to change rotary motion to reciprocating motion.

Elliot type axle: A front axle beam with "C" shaped yokes on each end which support the steering knuckles.

Frame: The metal structural parts that support the chassis and body of a vehicle and which in turn are supported by the wheels.

Frame gauges: Gauges hung from the frame to check frame alinement.

Friction bearing: A bearing that uses sliding action to reduce friction between parts.

Front-end geometry: The angular relationship between the front wheels with their attaching parts and the frame of the vehicle; includes caster, camber, steering axis of inclination, toe-in, and toe-out on turns.

Full-floating axle: A rear drive axle in which the driving shaft does not support the vehicle's weight but merely drives the wheel.

Hard steering: A situation in which more effort than normal is required to turn a vehicle at highway speeds.

Hotchkiss drive: A type of rear suspension in which the driving force of the rear wheels is transmitted to the frame through the rear springs.

Hydrolastic suspension: A type of suspension which uses rubber springs in conjunction with a water and alcohol hydraulic balancing system.

Idler arm: A link used to support one end of a tie rod or drag link and which transfers steering action from the steering gear to the steering arms.

Included angle (steering): The angle formed by drawing center lines through the steering axis and center of the wheel when viewed from the front of the vehicle; includes camber angle plus steering axis of inclination.

Independent suspension: A type of suspension system that permits each wheel to move up and down with little affect on the other wheels.

Inertia: The force which tends to keep a stationary body at rest or a moving body in motion until acted upon by some outside force.

Jiggler: A device used with some on-the-car wheel balancers that has a point which vibrates when the wheel is out of balance.

Kingpin: A hardened steel pin that passes through the steering knuckle and axle end.

Kingpin inclination (kpi): The tilt of the tops of the kingpins inward from the vertical centerline of the wheel. Also called steering axis inclination.

Lead: The tendency of a vehicle to pull to one side of the road.

Leaf spring: A type of suspension spring made up of one or more pieces of flat spring steel.

Linkage power steering: A type of power steering in which the power units (power cylinder and valve) are part of the steering linkage.

Live axle: An axle which holds and drives the wheel.

Locknut: A nut turned down against a holding nut in order to prevent loosening.

Longitudinal leaf spring: A leaf spring mounted parallel to the length of the vehicle.

Loose steering: Excessive motion in a steering system.

Low pivot swing axle: A rear axle design in which the differential housing is attached to the frame by a pivot mount.

"Mag" wheel: A trade name for a special type of wheel.

Needle bearing: A bearing composed of many small diameter rollers fitted into a race.

"O" ring: A ring made of special rubber-like material which is fitted into grooves to provide a sealing action.

Oversteer: The tendency for a vehicle negotiating a corner to turn more sharply than the driver intended.

Parallelogram steering linkage: A type of steering system that uses two short tie rods which are connected to the steering arms and a long center link. The center link is supported by an idler arm on one end and is attached directly to the pitman arm on the other end. This arrangement forms a parallelogram.

Pitman arm: A short arm which transmits the steering force from the steering gear cross-shaft to the steering linkage.

Pitman-arm stop: A device used on some cars (mainly those using linkage power steering) to prevent excessive pitman-arm travel.

Power cylinder: A device used to produce the force needed to activate a mechanism or system.

Power rack: A rack used in some power steering units to transmit force from the power cylinder to the pitman shaft.

Power steering: A type of steering system that uses hydraulic pressure to reduce the driver's turning effort.

Preloading: The application of a small amount of pressure to an antifriction bearing to eliminate any play in the system.

p.s.i.: Pounds per square inch.

Rack-and-pinion steering: A type of steering in which a pinion on the end of the steering shaft meshes with a rack on the main crossmember of the steering linkage.

Radial-bias tire: A type of tire construction in which the plies are constructed perpendicular to the rim and with a circumferential belt placed on top them.

Reamer: A metal-cutting tool with a series of sharp fluted cutting edges used to remove material accurately to a finished diameter.

Recirculating ball: A type of steering system that uses a series of steel balls that feed through grooves cut in the worm which engage a nut and cause it to move along the worm.

Relief valve: A type of valve that opens when a preset pressure is reached.

Reverse Elliot type axle: A front axle beam with ends that fit into the yoke of the steering knuckles; commonly used on trucks.

Road feel: The vibrations or feedback given to the driver through the steering wheel relative to the handling qualities of a vehicle in motion.

Road shock: The vibrations given to the steering wheel by depressions or obstacles in the road.

Scuff gage: A device used to check toe-in.

Sector: A section of a gear.

Shackle: A device used to fasten the end of a leaf spring to the chassis.

Shim: A thin piece of material installed between two objects to increase the distance between them.

Shimmy: A condition in which the front wheels of a vehicle move rapidly from side to side without any apparent external force.

Shock absorber: A device used to control spring oscillations.

Skid: The condition when a tire fails to maintain traction with the road surface.

Slip angle: The difference between the actual path taken by a vehicle going around a turn and the path the vehicle would have taken if it had gone in the exact direction that the wheels were pointed.

Snubber: A device that limits the movement of some part.

Spindle: The machined shaft of the steering knuckles on which the front wheel bearings are mounted.

Spool valve: A hydraulic control valve shaped somewhat like a spool used in a power steering control unit.

Spring: A device that yields under pressure and returns to its original position after the pressure is removed.

Spring booster: A device used to increase the load capacity of standard springs.

Spring windup: The shape taken by rear leaf springs during acceleration or braking.

Sprung weight: The weight of all the parts of a vehicle that are supported by the suspension.

Stabilizer bar: A spring steel bar that controls and minimizes body lean on corners. Also called a sway bar.

Static balance: The even distribution of the weight mass around the axis of rotation.

Steering arm: The part of the steering knuckle that attaches to the tie rod.

Steering axis: The centerline through the ball joints in a front suspension system.

Steering axis inclination: The tilt of the tops of the kingpins inward from the vertical centerline of the wheel. Also called kingpin inclination.

Steering gear: The gears on the lower end of the steering column that multiply the force applied to the steering wheel.

Steering geometry: The various angles involved in the front end suspension and alinement of a vehicle.

Steering kick back: The rapid movements of the steering wheel when the front wheels encounter obstructions in the road.

Steering knuckle: The part of the spindle that pivots on either a kingpin or ball joints.

Steering knuckle angle: The angle formed between a line through the ball joints of a front suspension and the centerline of the spindle. Also called the included angle.

Steering post or column: The shaft that connects the steering gear unit with the steering wheel.

Steering wheel: The wheel at the top of the steering shaft which is used to guide the vehicle.

Suspension arm: The part of the front suspension that is pivoted to the frame at one end and to the steering knuckle support at the other end.

Swing axle: A rear suspension system in which each driving wheel is able to move up or down independently.

Thrust bearing: A bearing designed to resist side pressure.

Thrust washer: A bronze or a hardened steel washer placed between two moving parts to provide a bearing surface and prevent longitudinal movement.

Tie rod: A rod in the steering system that connects the pitman arm to the steering knuckle arms.

Tilt steering wheel: A type of steering wheel that can be tilted at various angles.

Tire balance: The condition in a wheel when the weight mass is evenly distributed around the axis of rotation.

Tire bead: The part of the tire that bears against the rim flange.

Tire plies: The layers of fabric that form the casing of a tire.

Tire rotation: Changing the location of the tires on a vehicle to equalize any irregularities in wear.

Tire sidewall: The part of the tire between the tread and the bead.

Tire tread: The part of the tire that contacts the road.

Toe-in: The condition in which the distance between the front part of the wheels is less than the distance between the rear part of the wheels.

Toe-out on turns: A design that allows the inner wheel to turn more sharply than the outer wheel as a vehicle goes around a corner.

Tolerance: A permissible variation between two extremes of a specified dimension.

Torque: A turning or twisting force.

Torque tube drive: A type of rear suspension in which the driving force of the rear wheels is transmitted to the frame through a torque tube surrounding the drive shaft.

Torque wrench: A special wrench that indicates the amount of force being applied to a bolt or nut.

Torsion bar: A long spring steel rod so attached that it provides a spring action when its free end is twisted.

Torsion bar suspension: A suspension system that uses torsion bars in place of leaf or coil springs.

Track: The distance between the wheels on one axle.

Tracking: The condition in which the rear wheels follow the path made by the front wheels.

Traction bar: A bar or link attached to the frame and rear axle housing to prevent spring windup during heavy acceleration or braking.

Tramp: The hopping motion of the front or rear wheels at high speeds due to an unbalanced condition or excessive wheel runout.

Transaxle: A drive design in which the transmission and differential are combined into a single unit.

Transverse leaf spring: A leaf spring mounted at right angles to the length of the car.

Tread: The part of the tire which contacts the roadway.

Troubleshooting: The investigation necessary to determine the cause of a problem. Also implies correction by eliminating the cause.

Turning radius: The radius of the smallest circle which a vehicle can be turned.

"U" bolt: A bolt used to attach the spring to the rear axle.

Understeer: The tendency for a car negotiating a corner to turn less sharply than the driver intended.

Unit body: A body of a vehicle which acts as the frame.

Unsprung weight: All the parts of a vehicle that are not supported by the suspension, wheels, and tires.

Wandering: The condition in which the steered wheels of a vehicle vary from their intended path causing interference with the directional control of the vehicle.

Wheel aliner: A device used to check camber, caster, and toe-in.

Wheel balancer: A device used to check the balance of a wheel either statically or dynamically.

Wheelbase: The distance between the centerline of the front wheels and the centerline of the rear wheels.

Wheel hop: The bouncing action of the wheels during heavy acceleration or braking.

Wheel runout: A lack of alinement of the wheel to the axle which causes the wheel to wobble as it rotates.

Wheel tramp: A hopping motion of the front wheels that causes vibrations at high speeds.

Wide treads; wide oval: Tires in which the heighth, bead to tread surface, is about 60 or 70 percent of the width across outside of carcass.

Worm gear: A spiral shaped gear cut on a shaft; used on the lower end of the steering shaft.

Worm and roller: A type of system that uses a roller on one end of the cross-shaft to engage the worm gear on the steering shaft.

Worm and sector: A type of steering system that uses a worm gear to engage a section (portion of a gear) on the cross-shaft.

Worm and taper pin: A type of steering system that uses a tapered pin at the end of the cross-shaft to engage the worm gear on the steering shaft.

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