

Automotive Steering, Suspension, & Alignment 7e

Chapter 18 WHEEL ALIGNMENT PRINCIPLES

Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This course or class covers operation and service of Automotive Steering and Suspension Systems with Wheel Alignment and Drive Axles . It correlates material to task lists specified by ASE and NATEF
Motivate Learners	Explain how the knowledge of how something works translates into the ability to use that knowledge to figure why the engine does not work correctly and how this saves diagnosis time, which translates into more money.
State the learning objectives for the chapter or course you are about to cover and explain this is what they should be able to do as a result of attending this session or class.	<p>Explain learning objectives to students as listed below:</p> <ol style="list-style-type: none"> 1. Define wheel alignment and discuss alignment-related problems. 2. Define caster, toe, and SAI. 3. Discuss included angle, scrub radius, turning radius, setback, and thrust angle. <p>This chapter will help prepare for ASE Suspension and Steering (A4) certification test content area "D" (Wheel Alignment Diagnosis, Adjustment, and Repair).</p>
Establish the Mood or Climate	Provide a WELCOME , Avoid put downs and bad jokes.
Complete Essentials	Restrooms, breaks, registration, tests, etc.
Clarify and Establish Knowledge Base	Do a round robin of the class by going around the room and having each student give their backgrounds, years of experience, family, hobbies, career goals, or anything they want to share.

NOTE: This lesson plan is based on Automotive Steering, Suspension, & Alignment 7th Edition Chapter Images found on Jim's web site @ www.jameshalderman.com
LINK CHP 18: [Chapter Images](#)

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1. SLIDE 1 CH18 WHEEL ALIGNMENT PRINCIPLES

Check for **ADDITIONAL VIDEOS & ANIMATIONS @**
<http://www.jameshalderman.com/>
WEB SITE IS CONSTANTLY UPDATED

Alignment (31 Links)

At the beginning of this class, you can download the crossword puzzle & Word Search from the links below to familiarize your class with the terms in this chapter & then discuss them

Crossword Puzzle (Microsoft Word) (PDF)

Word Search Puzzle (Microsoft Word) (PDF)

DISCUSSION: discuss the possible causes of lead or drift.

2. **SLIDE 2 EXPLAIN Figure 18-1** A pull is usually defined as a tug on the steering wheel toward one side or the other.
3. **SLIDE 3 EXPLAIN Figure 18-2** crown of the road refers to the angle or slope of the roadway needed to drain water off the pavement
4. **SLIDE 4 EXPLAIN Figure 18-3** Wander is an unstable condition requiring constant driver corrections

DISCUSSION: discuss how to distinguish a wander from a pull. Ask students to discuss why some customers may think they need an alignment when they actually have a tire balance problem.

5. **SLIDE 5 EXPLAIN Figure 18-4** Positive camber. The solid vertical line represents true vertical, and the dotted line represents the angle of the tire

Wheel Alignment, Camber

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6. **SLIDE 6 EXPLAIN Figure 18-5** Negative camber. The solid vertical line represents true vertical, and the dotted line represents the angle of the tire.
7. **SLIDE 7 EXPLAIN Figure 18-6** Zero camber. Note that the angle of the tire is true vertical.

A "V" for victory is a positive thing. This will help you remember tires out at the top make a "V," and that's positive camber.

DEMONSTRATION: Show the students examples of shims, slots, and eccentric cams.

8. **SLIDE 8 EXPLAIN Figure 18-7** Excessive positive camber and how the front tires would wear due to the excessive camber.
9. **SLIDE 9 EXPLAIN Figure 18-8** Excessive negative camber and how the front tires would wear due to the excessive camber.
10. **SLIDE 10 EXPLAIN Figure 18-9** Positive camber tilts the tire and forms a cone shape that causes the wheel to roll away or pull outward toward the point of the cone.
11. **SLIDE 11 EXPLAIN Figure 18-10** Negative camber creates a pulling force toward the center of the vehicle.
12. **SLIDE 12 EXPLAIN Figure 18-11** If camber angles are different from one side to the other, the vehicle will pull toward the side with the most camber.
13. **SLIDE 13 EXPLAIN Figure 18-12** Positive camber applies vehicle weight toward larger inner wheel bearing. This is desirable because larger inner bearing is designed to carry more vehicle weight than smaller outer bearing.
14. **SLIDE 14 EXPLAIN Figure 18-13** Negative camber applies the vehicle weight to the smaller outer wheel bearing. Excessive negative camber, therefore, may contribute to outer wheel bearing failure.

Wheel Alignment, Caster

15. **SLIDE 15 EXPLAIN Figure 18-14** Zero caster
16. **SLIDE 16 EXPLAIN Figure 18-15** Positive (+) caster.
17. **SLIDE 17 EXPLAIN Figure 18-16** Negative (-) caster is seldom specified on today's vehicles because it tends to make the vehicle unstable at highway speeds. Negative caster was

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specified on some older vehicles not equipped with power steering to help reduce the steering effort

18. **SLIDE 18 EXPLAIN Figure 18-17** As spindle rotates, it lifts the weight of the vehicle due to the angle of the steering axis

Person with a negative attitude drags their feet. This will help you remember that when the lower ball joint (feet) is behind the upper ball joint (head), CASTER IS NEGATIVE

DISCUSSION: Ask the students to discuss how to tell if an older vehicle has negative caster.

DISCUSSION: Ask the students to discuss how to eliminate outside shoulder wear on the front tires caused by positive caster on vehicles used exclusively for city driving

On an older vehicle, if non-radial tires are replaced by radial tires, check caster. It may need to be readjusted to positive.

19. **SLIDE 19 EXPLAIN Figure 18-18** Vehicle weight tends to lower spindle, which returns steering to straight-ahead position
20. **SLIDE 20 EXPLAIN Figure 18-19** High positive caster provides a road shock path to vehicle.
21. **SLIDE 21 EXPLAIN Figure 18-20** steering dampener is used on many pickup trucks, sport utility vehicles (SUVs), and many luxury vehicles designed with a high-positive-caster setting. The dampener helps prevent steering wheel kickback when the front tires hit a bump or hole in the road and also helps reduce steering wheel shimmy that may result from high-caster setting
22. **SLIDE 22 EXPLAIN Figure 18-21** As load increases in the rear of a vehicle, the top steering axis pivot point moves rearward, increasing positive (+) caster.
23. **SLIDE 23 EXPLAIN FIGURE 18-22** Note how front tire becomes tilted as vehicle turns a corner with positive caster. Higher caster angle, more front tires tilt, causing camber-type tire wear.

[Toe-in, RWD Vehicle \(View\) \(Download\)](#)

[Toe-out, FWD Vehicle \(View\) \(Download\)](#)

[Wheel Alignment, Toe \(View\) \(Download\)](#)

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24. **SLIDE 24 EXPLAIN** Figure 18-23 Zero toe. Note how both tires are parallel to each other as viewed from above the vehicle.
25. **SLIDE 25 EXPLAIN** Figure 18-24 Total toe is often expressed as an angle. Because both front wheels are tied together through the tie rods and center link, the toe angle is always equally split between the two front wheels when the vehicle moves forward.
26. **SLIDE 26 EXPLAIN** Figure 18-25 Toe-in, called positive (+) toe
27. **SLIDE 27 EXPLAIN** Figure 18-26 Toe-out, also called negative (-) toe

DEMONSTRATION: Show examples of tires with wear caused by excessive toe-out. Show examples of tires with feather-edge wear and diagonal wear. Show how to adjust the toe on the front of a vehicle by turning the tire rod sleeve. **FIGURE 18-24**

HANDS-ON TASK: Have the students adjust the toe on front of a vehicle by turning tire rod sleeve

28. **SLIDE 28 EXPLAIN** Figure 18-27 This tire is just one month old! It was new and installed on the front of a vehicle that had about 1/4 inch (6 mm) of toe-out. By the time the customer returned to the tire store for an alignment, the tire was completely bald on the inside. Note almost new tread on outside.
29. **SLIDE 29 EXPLAIN** Figure 18-28 Excessive toe-out and the type of wear that can occur to the side of both front tires.
30. **SLIDE 30 EXPLAIN** Figure 18-29 Excessive toe-in and the type of wear that can occur to the outside of both front tires.
31. **SLIDE 31 EXPLAIN** Figure 18-30 Feather-edge wear pattern caused by excessive toe-in or toe-out.

DEMONSTRATION: Show how to determine feathered or sawtooth tread wear by rubbing hand across tread of tire: **FIGURE 18-28, 29, 30**

HANDS-ON TASK: Have the students determine if a tire has feathered tread wear by rubbing their hands on the tire: **FIGURE 18-28, 29, 30**

32. **SLIDE 32 EXPLAIN** Figure 18-31 Rear toe-in (+). The rear toe (unlike the front toe) can be different for each wheel while the vehicle is moving forward because the rear wheels are not tied together as they are in the front

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33. **SLIDE 33 EXPLAIN Figure 18-32** Incorrect toe can cause the tire to run sideways as it rolls, resulting in a diagonal wipe
34. **SLIDE 34 EXPLAIN Figure 18-33** Diagonal wear such as shown here is usually caused by incorrect toe on the rear of a front-wheel-drive vehicle
35. **SLIDE 35 EXPLAIN Figure 18-34** Toe on front of most vehicles adjusted by turning tie rod sleeve as shown
36. **SLIDE 36 EXPLAIN FIGURE 18-35** While the feathered or sawtooth tire tread wear pattern may not be noticeable to the eye, this wear can usually be felt by rubbing your hand across the tread of the tire.

A vehicle with excessive toe will “dart” to the side that has traction when one front tire loses traction on ice.

37. **SLIDE 37 EXPLAIN Figure 18-36** The left illustration shows that the steering axis inclination angle is determined by drawing a line through the center of the upper and lower ball joints. This represents the pivot points of the front wheels when the steering wheel is rotated during cornering. The right illustration shows that the steering axis inclination angle is determined by drawing a line through the axis of the upper strut bearing mount assembly and the lower ball joint.
38. **SLIDE 38 EXPLAIN Figure 18-37** The SAI causes the spindle to travel in an arc when the wheels are turned. The weight of the vehicle is therefore used to help straighten the front tires after a turn and to help give directional stability

[Wheel Alignment, Steering Axis Inclination & Included Angle \(View\) \(Download\)](#)

Most frequent cause of Steering Axis Inclination (SAI) is bent parts, make visual search for bent parts before beginning [FIGURE 18-36](#)

[DISCUSSION: Ask students to discuss why SAI is greater in strut suspension than in short/long-arm suspension](#)

39. **SLIDE 39 EXPLAIN Figure 18-38** Included angle on a MacPherson-strut-type suspension.
40. **SLIDE 40 EXPLAIN Figure 18-39** Included angle on an SLA-type suspension. The included angle is the SAI angle and

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the camber angle added together.

41. **SLIDE 41 EXPLAIN Figure 18-40** Cradle placement. If the cradle is not replaced in exact position after removal for a transmission or clutch replacement, SAI, camber, included angle will not be equal side-to-side

If included angle is high on one side and low on other side, shifted cradle could be problem: FIGURE 18-39

42. **SLIDE 42 EXPLAIN Figure 18-41** positive scrub radius (angle) is usually built into most SLA front suspensions, and a negative scrub radius is usually built into most MacPherson-strut-type front suspensions.
43. **SLIDE 43 EXPLAIN Figure 18-42** With negative scrub radius, the imaginary line through the steering axis inclination (SAI) intersects the road outside of the centerline of the tire. With positive scrub radius, the SAI line intersects the road inside the centerline of tires.
44. **SLIDE 44 EXPLAIN Figure 18-43** With a positive scrub radius, the pivot point, marked with a + mark, is inside the centerline of the tire and will cause the wheel to turn toward the outside, especially during braking. Zero scrub radius does not create any force on the tires and is not usually used on vehicles because it does not create an opposing force on the tires, which in turn makes the vehicle more susceptible to minor bumps and dips in the road. Negative scrub radius, as is used with most front-wheel-drive vehicles, generates an inward force on tires.

DISCUSSION: Ask the students to discuss why positive scrub radius is commonly used on RWD vehicles. Ask the students to discuss how to overcome the problems caused by the scrub radius becoming positive during installation of larger diameter tires and positive-offset wheels. FIGURE 18-41, 42

DISCUSSION: Ask the students to discuss how a repair history could help diagnose a tire wear problem

45. **SLIDE 45 EXPLAIN Figure 17-44** To provide handling, the inside wheel has to turn at a greater turning radius than the outside wheel
46. **SLIDE 46 EXPLAIN Figure 17-45** proper toe-out on turns is achieved by angling the steering arms.

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QUESTION

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Turning Radius (View) (Download)

DEMONSTRATION: Using string and a plumb bob, show the students how the steering arms line up with the center of the rear axle: **TOOT: FIGURE 18-45**

HANDS-ON TASK: Have the students use a chalk line and protractor to measure toe-out on turns. Have them snap a line parallel with each front tire, then turn the front wheels and snap new lines parallel to the wheels. Have the students use the protractor to check the angles.

47. SLIDE 47 **EXPLAIN** Figure 18-46 (a) Positive Setback & (B) Negative Setback
48. SLIDE 48 **EXPLAIN** Figure 17-47 Cradle placement affects setback

Wheel Alignment, Setback (View) (Download)

49. SLIDE 49 **EXPLAIN** Figure 18-48 (a) Zero thrust angle, (b) Thrust line to right, (c) Thrust line to left

Wheel Alignment, Thrust Angle (View) (Download)

50. SLIDE 50 **EXPLAIN** Figure 18-49 (a) Proper tracking & (b) Front wheels steering toward thrust line

Wheel Alignment, Track (View) (Download)

DISCUSSION: Ask the students to discuss the symptoms of dog tracking. Discuss causes of dog tracking: **FIGURE 18-49**

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If front & rear wheels are same diameter, it is faster to measure **wheel base** from front of one wheel to front of other wheel.

ON-VEHICLE NATEF TASK: Research applicable vehicle and service information, such as suspension and steering system operation, vehicle history, and TSBs.