Automotive Technology 6th Edition
Chapter 124 WHEEL ALIGNMENT PRINCIPLES
Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This Automotive Technology 6th text provides complete coverage of automotive components, operation, design, and troubleshooting. It correlates material to task lists specified by ASE and ASEEducation (NATEF) and emphasizes a problem-solving approach. Chapter features include Tech Tips, Frequently Asked Questions, Case Studies, Videos, Animations, and ASEEducation (NATEF) Task Sheets.
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.	Explain learning objectives to students as listed below: 1. Define wheel alignment and discuss alignment-related problems. 2. Discuss camber, caster, toe, and SAI. 3. Discuss included angle, scrub radius, turning radius, setback, and thrust angle.
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: Lesson plan is based on 6th Edition Chapter Images found on Jim's web site @ www.jameshalderman.com

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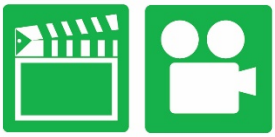
NOTE: You can use Chapter Images or possibly Power Point files:

ICONS	Chapter 124 Wheel Alignment Principles
	**1. SLIDE 1 CH124 WHEEL ALIGNMENT PRINCIPLES**
	**Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/** **WEB SITE IS CONSTANTLY UPDATED** **http://www.jameshalderman.com/automotive_principles.html** **DOWNLOAD** **Crossword Puzzle (Microsoft Word) (PDF)** **Word Search Puzzle (Microsoft Word) (PDF** **Videos**
	
	**DISCUSSION: Ask the students to discuss the possible causes of lead or drift.**
	**2. SLIDE 2 EXPLAIN Figure 124 -1 pull** is usually defined as tug on steering wheel toward one side or other. **3. SLIDE 3 EXPLAIN Figure 124 -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 124 -3** Wander is an unstable condition requiring constant driver corrections.
	**DISCUSSION: Ask the students to discuss how to distinguish a wander from a pull. Ask the 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 124-4** Positive camber. The solid vertical line represents true vertical, and the dotted line represents the angle of the tire. **6. SLIDE 6 EXPLAIN Figure 124-5** Negative camber. The solid vertical line represents true vertical, and the dotted line represents the angle of the tire. **7. SLIDE 7 EXPLAIN Figure 124-6** Zero camber. Note that the angle of the tire is true vertical.

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	**Wheel Alignment, Camber (View) (Download)**
	**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 124-7** Excessive positive camber and how front tires would wear due to excess 9. **SLIDE 9 EXPLAIN Figure 124-8** Excessive negative camber and how the front tires would wear due to the excessive camber. 10. **SLIDE 10 EXPLAIN Figure 124-9** 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 124-10** Negative camber creates a pulling force toward the center of the vehicle. 12. **SLIDE 12 EXPLAIN Figure 124-11** 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 124-12** 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 124-13** 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 (View) (Download)**
	15. **SLIDE 15 EXPLAIN Figure 124-14** Zero caster. 16. **SLIDE 16 EXPLAIN Figure 124-15** Positive (+) caster. 17. **SLIDE 17 EXPLAIN Figure 124-16** Negative (-) caster is seldom specified on today's vehicles because it tends to make vehicle unstable at highway speeds. Negative

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caster was specified on some older vehicles not equipped with power steering to help reduce steering effort.

18. **SLIDE 18 EXPLAIN Figure 124-17** 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: discuss how to eliminate outside shoulder wear on 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 124-18** Vehicle weight tends to lower the spindle, which returns the steering to the straight-ahead position.
20. **SLIDE 20 EXPLAIN Figure 124-19** High positive caster provides a road shock path to the vehicle.
21. **SLIDE 21 EXPLAIN Figure 124-20** A 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 124-21** As load increases in the rear of a vehicle, the top steering axis pivot point moves rearward, increasing positive (+) caster.

Wheel Alignment, Toe (View) (Download)

EXPLAIN TECH TIP: *Think of a Bicycle*

How caster affects steering stability and steering wheel returning to straight-ahead position after a turn is made easy by remembering how a bicycle

acts. Caster allows riders to travel straight ahead with their hands off handle bars because weight is behind axle.

EXPLAIN TECH TIP: ***Caster Angle Tire Wear***

The caster angle is generally considered to be a non-tire wearing angle. However, excessive or unequal caster can indirectly cause wear. When front wheels are turned on a vehicle with a lot of positive caster, they become angled. This is called camber roll. (Caster angle is a measurement of difference in camber angle from when wheel is turned inward compared to when wheel is turned outward.) Most vehicle OEMS have positive caster designed into suspension system. This positive caster increases directional stability. However, if vehicle is used exclusively in city driving, positive caster can cause tire wear to outside shoulders of both front tires. ● SEE FIGURE 124–22.

23. **SLIDE 23 EXPLAIN FIGURE 124-22** Note how the front tire becomes tilted as the vehicle turns a corner with positive caster
24. **SLIDE 24 EXPLAIN Figure 124-23** Zero toe. Note how both tires are parallel to each other as viewed from above the vehicle.
25. **SLIDE 25 EXPLAIN Figure 124-24** 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 124-25** Toe-in, also called positive (+) toe
27. **SLIDE 27 EXPLAIN Figure 124-26** 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 124-24

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	**HANDS-ON TASK: Have the students adjust the toe on front of a vehicle by turning tire rod sleeve**
	**28. SLIDE 28 EXPLAIN Figure 124-27** 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 the almost new tread on the outside. **29. SLIDE 29 EXPLAIN Figure 124-28** Excessive toe-out and the type of wear that can occur to the side of both front tires.
	**30. SLIDE 30 EXPLAIN Figure 124-29** Excessive toe-in and the type of wear that can occur to the outside of both front tires.
	**31. SLIDE 31 EXPLAIN Figure 124-30** Feather-edge wear pattern caused by excessive toe-in or toe-out. **DEMONSTRATION: Show how to determine feathered or sawtooth tread wear by rubbing a hand across tread of tire: FIG 124-28, 29, 30**
	**HANDS-ON TASK: Have the students determine if a tire has feathered tread wear by rubbing their hands on the tire: FIGURE 124-28, 29, 30**
	**32. SLIDE 32 EXPLAIN Figure 124-31** 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 front
	**33. SLIDE 33 EXPLAIN Figure 124-32** Incorrect toe can cause the tire to run sideways as it rolls, resulting in a diagonal wipe **34. SLIDE 34 EXPLAIN Figure 124-33** 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 124-34** Toe on the front of most vehicles is adjusted by turning the tie rod sleeve as shown

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    	**A vehicle with excessive toe will "dart" to the side that has traction when one front tire loses traction on ice.** **Most frequent cause of Steering Axis Inclination (SAI) is bent parts, make visual search for bent parts before beginning FIGURE 124-36** **DISCUSSION: Ask students to discuss why SAI is greater in strut suspension than in short/long-arm suspension** **DISCUSS FREQUENTLY ASKED QUESTION:** ***Why Doesn't Unequal Front Toe on the Front Wheels Cause the Vehicle to Pull?*** **Each wheel could have individual toe, but as vehicle is being driven, forces on tires tend to split toe, causing steering wheel to cock at an angle as front wheels both track same. If the toe is different on the rear of the vehicle, the rear will be "steered" similar to a rudder on a boat because rear wheels are not tied together as are front wheels.** **EXPLAIN TECH TIP: *Smooth In, Toed-In; Smooth Out, Toed-Out.* Whenever toe setting is not zero, a rubbing action occurs that causes a feather-edge-type wear. • SEE FIGURE 124–35. A quick, easy method to determine if incorrect toe could be causing problems is simply to rub your hand across tread of tire. If it feels smoother moving your hand toward center of vehicle than when you move your hand toward outside, then cause is excessive toe-in. The opposite effect is caused by toe-out. This may be felt on all types of tires, including radial-ply tires where the wear may not be seen as feather edged. Just remember this simple saying: "Smooth in, toed-in; smooth out, toed-out."**

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	**36. SLIDE 36 EXPLAIN FIGURE 124-35** While the feathered or sawtooth tire tread wear pattern may not be noticeable to eye, this wear can usually be felt by rubbing your hand across the tread of the tire. **37. SLIDE 37 EXPLAIN Figure 124-36** 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 124-37** 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.
	**39. SLIDE 39 EXPLAIN Figure 124-38** Included angle on a MacPherson-strut-type suspension. **40. SLIDE 40 EXPLAIN Figure 124-39** Included angle on an SLA-type suspension. The included angle is the SAI angle and the camber angle added together. **41. SLIDE 41 EXPLAIN Figure 124-40** Cradle placement. If the cradle is not replaced in the exact position after removal for a transmission or clutch replacement, the SAI, camber, and included angle will not be equal side-to-side.
	**120. SLIDE 120 EXPLAIN Included Angle** **If included angle is high on one side and low on other side, shifted cradle could be problem: FIGURE 124-39**
	**42. SLIDE 42 EXPLAIN Figure 124-41** 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 124-42** 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.

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	44. **SLIDE 44 EXPLAIN Figure 124-43** 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 the 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 124-41, 42
	**DISCUSSION: Ask the students to discuss how a repair history could help diagnose a tire wear problem**
	**Wheel Alignment, Turning Radius (View) (Download)**
	45. **SLIDE 45 EXPLAIN Figure 124-44** To provide handling, the inside wheel has to turn at a greater turning radius than the outside wheel.
	46. **SLIDE 46 EXPLAIN Figure 124-45** The proper toe-out on turns is achieved by angling the steering arms.
	**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 124-45
	**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.**

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	47. **SLIDE 47 EXPLAIN Figure 124-46a** Positive setback 48. **SLIDE 48 EXPLAIN Figure 124-46b** Negative setback. 49. **SLIDE 49 EXPLAIN Figure 124-47** Cradle placement affects setback.
	**Wheel Alignment, Setback (View) (Download)** **Wheel Alignment, Thrust Angle (View) (Download)**
	50. **SLIDE 50 EXPLAIN Figure 124-48a** Zero thrust angle. 51. **SLIDE 51 EXPLAIN Figure 124-48b** Thrust line to right. 52. **SLIDE 52 EXPLAIN Figure 124-48c** Thrust line to left 53. **SLIDE 53 EXPLAIN Figure 124.49a** Proper tracking. 54. **SLIDE 54 EXPLAIN Figure 124-49b** Front wheels steering toward thrust line.
	**DISCUSSION: Ask the students to discuss the symptoms of dog tracking. Discuss causes of dog tracking: FIGURE 124-49b** **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 ASEEDUCATION TASK:** **Research applicable vehicle and service information, such as suspension and steering system operation, vehicle history, and TSBs.**