Before We Begin…

Keeping in mind the Career Cluster of Transportation, Distribution & Logistics

Ask yourself:

What careers might be present in this slide series?

What careers might interest me?

How do these careers relate to my other high school classes?

What career cluster is my 4-year plan preparing me for?
ATASA 5th  Steering Systems

Diagram of steering systems showing:
- Frame bracket
- Idler arm
- Center link
- Pitman arm
- Tie-rod
- Tie-rod end
- Tie-rod ends

Front view
1. The purpose of the steering system is to turn the ________ wheels & in some cases the rears too.
4 - wheel steering
2. The steering system is composed of the steering ____________, steering _______ and the steering column and wheel.  

*Note: SIR/SRS is often grouped with steering ASE A4*
3. Steering linkage is the system of __________ and connecting __________ between the steering gear and the steering arms or knuckles attached to the wheels that control the direction of travel.
4. __________ linkage is the most common type on larger cars, pickups & larger SUV’s.
5. Any steering linkage can be placed either __________ of or __________ the front axle centerline.

Note: This will determine whether lengthening or shortening the tie rods will result in toe-in or toe-out.
Lengthen Tie Rods to get Toe In

Lengthen Tie Rods to get Toe Out
6. The ___________ _____ connects the steering linkage to the steering gear or steering box.
7. The pitman arm also maintains the height of the center link, this reduces chances of ______ steer.
NEW! Bithell Bump Steer Stem

With the combined effort of Chris Bithell, Houser Racing is introducing the NEW Reduced Bump Steer Steering Stem for the Honda TRX450 2004-05 front end with Houser A-Arms.

This steering stem was designed by Houser Racing to reduce/eliminate the excessive bump steer found on the Honda 2004-05 front end. The Bithell Bump Steer Steering Stem can also be used to reduce bump steer on 2006-07 Honda ATV that uses the Honda 2004-05 OEM Front Spindles matched with Houser A-Arms.

Part Numbers - Available in Black and Chrome

040610 - HON 2003-05 Black +0
040611 - HON 2003-05 Chrome +0
040612 - HON 2003-05 Black +1
040613 - HON 2003-05 Chrome +1
040614 - HON 2003-05 Black +2
040615 - HON 2003-05 Chrome +2
What is Bump Steer?

A. Definition

Bump Steer is when your wheels steer themselves without input from the steering wheel. The undesirable steering is caused by bumps in the track interacting with improper length or angle of your suspension and steering linkages.

Most car builders design their cars so that the effects of bump steer are minimal. However, you must still take care to bolt on your suspension carefully so as not to create unwanted bump steer. Make sure that you are always using the correct components for a particular car. Bump steer must be designed into the car and cannot be adjusted out if improper parts are used or if pivot points are moved without considering bump steer design principles.

In order to accomplish zero bump the tie rod must fall between an imaginary line that runs from the upper ball joint through the lower ball joint and an imaginary line that runs through the upper a-arm pivot and the lower control arm pivot. In addition, the centerline of the tie rod must intersect with the instant center created by the upper a-arm and the lower control arm (See diagram below).

The instant center is an imaginary point that is created by drawing a line from the upper a-arm ball joint through the a-arm pivot where it is intersected by an imaginary line that extends from the lower ball joint through the inner control arm pivot. Where the two imaginary lines intersect is the instant center.

Sounds complicated? Really it is very simple. To achieve zero bump the front end must be designed correctly. The tie rod must travel on the same arc as the suspension when the car goes through travel. Simply matching lengths and arcs to prevent any unwanted steering of the front tires.
BUMPSTEER causes your steering wheel to turn slightly as your front suspension cycles up and down, as when the car goes over a bump, or when the body rolls in a corner, or when the front end dives during heavy braking. This "self steering" happens because the tie rods and control arms are moving in different arcs. Instead of tracking with the lower control arm, the tie rod pushes or pulls the steering arm as the suspension goes up or down. That changes the steering angle of the wheel and makes the car respond exactly as if the steering wheel had been turned by a small amount.
RHD & LHD
Power & Manual
RRS Rack & Pinion

Column conversion kit
Easy fit bearing support
Universal joint

Easy bolt in brackets using original steering box & idler arm holes

Light weight alloy centre steer rack

Bump steer correction

Patented linear tracking

Tie rod ends

Easy to service

Note: Center-Pull Rack & Pinion Steering Gear
A Tutorial: The anti-roll bar is essentially a transverse-mounted torsion bar designed to reduce body-roll during turns. It exerts no influence on the suspension when wheels bounce in unison. If vertical movement on one side exceeds the vertical movement on the other, the anti-roll bar exerts an opposing force. Along with its primary function of reducing body-roll, the anti-roll bar will also reduce the combined cornering force and the adhesion limits of the side-by-side tires that are being acted upon. Consequently, the location and stiffness of the bar can be modified to influence the oversteering or understeering characteristics of the vehicle.

An oversteering tendency will be reduced by locating the anti-roll bar at the front where it will reduce the cornering force and adhesion of the front tires.

If the vehicle understeers, the anti-roll bar should be located at the rear. If an anti-roll bar is already required at both ends of the vehicle to achieve adequate roll stiffness, use an anti-roll bar of greater stiffness/diameter at the end of the vehicle where reduced cornering force is desired, and use a less-stiff/smaller-diameter bar at the other end. (http://www.rqriley.com/suspensn.html)
8. The ________ ______ connects the steering linkage to the frame opposite of the pitman arm.
9. Pitman arms can be either wear or non-wear. Idler arms tend to wear ______ than pitman arms.
10. The ___________ _______ or drag link is the steering component that connects to the idler and pitman arms on either side and also to the inner tie rod ends. *They can also be either wear or non-wear.*
11. ______ ________ connect the center links to the steering knuckles.
12. Tie rods consist of an adjustment __________ in the center connecting to inner and outer, spring-loaded ball & socket ends. These are the components adjusted in order to achieve proper toe settings.

Rack & Pinion

Tie Rod Assembly

Outer Tie Rod End  Inner Tie Rod End
13. _______ & __________ steering linkage is lighter in weight with fewer components and provides quicker response as compared to parallelogram linkage.

** Rack & Pinion steering systems have no idler arm, pitman arm, or center link!**
14. On rack & pinion systems, a small __________ gear attached to the steering column moves a toothed ______ that is attached to the tie rods. The rack performs the task of the center link.
15. The rack & pinion assembly is housed in a tube with rubber __________ boots covering the inner tie rod ends to protect them from contamination by road elements like salt, sand & gravel. *No fluid in the bellows!*
16. The metal housing of the rack maintains the correct ______________ of the steering components similar to the way the center link, idler arm, and pitman arm do to prevent bump steer.
ATASA 5th  Steering Systems

- A. CV Driveshaft
- B. Bellows
- C. Rack and Pinion Steering Gear
- D. Sway Bar Mount Bushing
- E. MacPherson Strut Assembly
- F. Coil Spring
- G. Lower Control Arm and Ball Joint Assembly
- H. Ball Joint
- I. Control Arm Bushing
17. Rack-to-pinion yoke ________ or preload affects steering harshness, feedback, and noise. *This adjustment is done with either shims, and adjustment plug or an adjustment screw.*
18. Styles of steering gears can be ____________ ball, ________ & roller, and rack & pinion.
19. In addition to air bags & collapsible materials, steering columns are fit with ________________ joints to allow the pivot needed to reach through the passenger compartment to the steering gear.

This is a Rag Joint!!
ATASA 5th Steering Systems

- Rag Joint
- Manual Worm & Sector Gearbox
- Pitman Arm
20. Steering column design differences include: fixed column, _________ column, ________ column, and column-mounted transmission shift mechanisms. *Air bags are mounted there too.*
Evidence that toe adjustment is needed is if the spokes of the steering wheel are not centered!
21. A steering __________ is a horizontally mounted shock absorber that connects to the ______ link at one end and the frame at the other. They reduce road shock being transmitted through the steering system up the steering column, to the driver. *Found mostly on 4WD vehicles.*
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22. __________-________________ systems reduce the amount of effort needed to turn the steering wheel. They can be hydraulic units or can be electric motor driven and electronically controlled.
ATASA 5th Steering Systems

Diagram: Vehicle speed input to ECU, which controls the motor and torque sensor. Column Drive shown with ECU connection. Additional diagram showing EMPS ECU with inputs from Rear Wheel Speed Sensors, Brake ECU, Torque Sensor Signal 1, and Torque Sensor Signal 2.
23. On an ______________ piston power steering system, the power cylinder & control valve are both housed within the steering gear itself. Both recirculating ball & rack and pinion systems use this.
24. Power steering ________ develop hydraulic flow which provides the force needed to operate the steering gear. Pumps can be either roller, vane, slipper or gear designs. Pumps are typically belt driven.
25. __________ power steering (EPS), that uses either a 12-volt or 42-volt electric motor mounted to or mounted inside the steering gear replace the conventional fluid pump, hoses & drive belt.
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ATASA 5th  Steering Systems

EPS Block Diagram
26. Power steering uses both _______ control & pressure _________ valves in addition to a sensor which can signal the need for an RPM increase to the PCM under heavy steering load/psi at idle.  (*PSP sensor*)

Options: Flow, Relief
Flow, Volume
Flow, Vacuum
ATASA 5th Steering Systems

Typical Steering Circuit
27. Power steering __________ transmit fluid under pressure, return fluid, act as reservoirs as well as sound and vibration dampeners.

**Hose pressure may reach up to 1,500 psi with temperatures up to 300 degrees.**
28. ____ can change steering effort for parking vs. high speed driving & has made self-park a reality. (Necessary on Hybrid vehicles in EV mode)
29. Electric rack & pinion steering (EPS) may need up to ____ amperes to turn the wheel.
30. If the engine stalls, EPS still provides assist since the battery is the power source.  **True or False**
31. Steering system complaints include, excessive steering wheel ________, feedback, _________ steering, nibble (*a feeling similar to shimmy*), pulling, drift, shimmy, poor return, noise & wander.
32. With any diagnosis, you should begin by trying to verify & duplicate the ________ complaint.

*Repairs should follow the 3 C’s: verify Complaint, determine Cause, make Correction.*
33. Road tests, visual inspections, and above all, a check of the _______ level & condition is smart. (smell, feel, color)
34. A ___________ ______ is an electronic, inductive pick-up tool for noise identification.
35. Besides steering the wheel from lock-to-lock, there is also a vacuum method to __________ a power steering system of trapped air. Bubbles in the fluid indicate trapped air & cause noise.
36. A power steering ___________ tester helps determine pump & valving problems. On EPS, a scan tool is used to read DTC’s. There are also many mechanical parts to cause problems too.
CAUTION
During the power steering pump pressure test with the pressure gauge valve closed, if this valve is closed for more than 10 seconds, excessive pump pressure may cause power steering hoses to rupture, resulting in personal injury.

With the engine idling, close the pressure gauge valve for no more than 10 seconds, and observe the pressure gauge reading. Turn the pressure gauge valve to the fully open position. If the pressure gauge reading does not equal the vehicle manufacturer's specifications, repair or replace the power steering pump.

With the engine running, turn the steering wheel fully in one direction, and observe the steering pump pressure while holding the steering wheel in this position. If the pump pressure is less than the vehicle manufacturer's specifications, the steering gear housing has an internal leak and should be replaced or repaired.
37. Steering & suspension systems are best inspected with vehicle weight on them. True or False

...and adjustments are most often made with the weight on the steering & suspension systems too.

Prevents “Memory Steer”
38. The _______ ____ is the weakest link in the parallelogram steering system.
39. Any movement over ___” on a tie rod or joint on a center link is excessive.
40. A steering damper that is dripping oil should be replaced. **True or False**
41. A ______ _______ check is done with full vehicle weight on the system rocking the steering wheel back & forth....& measuring play of course!

A good way to inspect the steering linkage is to do a "dry park" check. This test involves rocking the steering back and forth with the full weight of the vehicle on the wheels (use a ramp type lift). By loading the rack and steering linkage this way, any play in the system becomes quickly obvious.

Start the dry park check by leaving the steering column unlocked and reaching up and rocking the steering input shaft from underneath the vehicle. Or, have a helper rock the steering wheel from inside the car while you observe the following points for play:

1. Steering input shaft coupling — The coupling must turn freely without binding, making noise or wobbling. Rubber sandwich-type flexible couplings must be free from cracks or tears.
2. Outer tie rod ends — No visible play should be observed. Also rotate the tie rod by hand to check for binding.
3. Inner sockets — Either by pinching the bellows or by sliding the bellows back for direct observation, you should see no visible motion. The condition of the bellows is extremely important because they keep out contaminants. A crack, tear or split in the bellows can allow dirt and moisture to ruin the inner socket. The formation of rust on the rack shaft can also destroy the rack seals. That’s why the bellows should be inspected every time a vehicle is up in the air — and replaced immediately if found to be defective.
4. Rack mounts — There should be no relative movement between the rack and chassis. Also look for cracked or broken rack ears.
42. Turning __________ can be measured with a pull scale fastened to a steering wheel spoke.
43. Steering gear lash adjustment *(felt as drag)* is checked with a __________ wrench at the steering wheel and the pitman arm disconnected from the steering gear box.
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44. Bleeding or ____________ a power steering system removes trapped air.
45. System service also often includes ______________ out the old fluid and replacing it with new.
46. _______-________ steering systems can provide near neutral steering for quicker cornering, better straight line stability, and a reduced turning circle. *4WS may be mechanical or electro/hydraulic*
47. Quadrasteer® is a 4WS system where at **low speeds** the rear wheels turn in ______________ directions from the fronts, at **moderate speeds** the rears are straight, and at **high speeds** the rear wheels turn in the same direction as the fronts.
47. Quadrasteer® is a 4WS system where at low speeds the rear wheels turn in ________ directions from the fronts, at moderate speeds the rears are straight, and at high speeds the rear wheels turn in the same direction as the fronts.
GMC Sierra Denali 4WS has a turning diameter of 37.4 ft, down from 46.2 ft in normal 2WS mode.
ATASA 5th Steering Systems
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How Car Steering Works

- Steering wheel
- Steering shaft
- Pinion
- Rack
- Tie rod
- Steering Arm
- Wheel
- Spindle

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Steering linkage components

- Pitman arm
- Frame bracket
- Idler arm
- Center link
- Socket
- Tie-rod
- Sockets
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1. Steering column assembly
2. Steering column
3. Intermediate shaft
4. Universal joint
5. Power-assisted steering system
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Formula One Steering Wheel: $40,000.
Zero camber means wheels are perpendicular to road, minimizing tire wear. Negative (inward tilt) or positive camber (outward tilt) cause irregular tire wear. Wheels that toe-in or toe-out at highway speeds scuff and wear unevenly.
MAC PHERSON STRUT SUSPENSION WITH RACK & PINION STEERING

Control Coil® Springs for MacPherson Struts
Variable rate design gives more control during braking and cornering, and resists bottoming out.

Remanufactured Rack & Pinion Units
Power and Manual
Restores steering ease and response. All remanufactured Rack and Pinion units have a limited lifetime warranty.

C.V. Joints
Drive Shafts, Service Kits, and Superboot® Sets
Replacement of worn boots and joints can reduce front-end noise and vibration, and can prevent more costly repair.
CONVENTIONAL SUSPENSION & PARALLELOGRAM STEERING

- Upper Ball Joint
- Tie Rod End Adjusting Sleeve
- Idler Arm
- Center Link
- Coil Spring
- Lower Control Arm Bushing
- Swaybar Link Kit
- Lower Ball Joint
- Upper Control Arm Bushing
- Control Arm Shaft
- Tie Rod End
- Swaybar
- Swaybar Bushing
ATASA 5th Steering Systems

- Steering Column
- Fluid Lines
- Rotary Valve
- To Reservoir
- From Pump

Rack, Piston, Pinion
Rack and pinion steering system

- Steering wheel
- Steering column
- Steering pump
- Steering gear
- Outer tie rod
- Inner tie rod
- Outer tie rod
- Inner tie rod
Upper and lower control arm suspension using torsion bars
- Visually inspect tie-rod ends, steering gearbox and boots every 15,000 miles
- Under severe operating conditions, visually inspect tie-rod ends, steering gearbox and boots every 7,500 miles
- Rotate tires every 7,500 miles
ATASA 5th Steering Systems

- **Positive Camber**
- **Negative Camber**

Diagram showing:
- A - B = "-" for Toe In
- A - B = "+" for Toe Out
Scrub radius is the distance from the centerline of the tire/wheel to where the kingpin line intersects with the road surface. The larger the distance, the more effort is required to turn the wheel, as the wheel has to "scrub" slightly to turn around the kingpin axis.
ATASA 5th  Steering Systems
Toe-Out on Turns

Outside wheel is at 18 degrees

Inside wheel is at 20 degrees

Steering Arm
Ackerman Principle

1. design having wheel spindles mounted on axle ends to permit
   spindles to be turned at an angle to axle for steering purposes;
2. the creation of toe-out when turning to minimize tire wear. To create
   the proper geometry, the steering arms are angled to turn the inside
   wheel at a sharper angle than the outside wheel. This allows the
   inside wheel to follow a smaller radius circle than the outside wheel.
ATASA 5\textsuperscript{th} Steering Systems
ATASA 5th  Steering Systems

- Direct fuel injection
- Active suspension
- Electric throttle valve control
- Brake-by-wire
- Electrically assisted power steering
- Steer-by-wire
- 42-V converter
**Tight vs. Loose Conditions and Adjustments**

**Tight:** Also known as understeer. This occurs when the front wheels lose traction before the rear wheels. It causes the stock car to have trouble steering sharply and smoothly through the turns as the front end pushes forward.

**Loose:** Also known as oversteer. This occurs when the rear tires of the stock car have trouble sticking in the corners. This causes the car to "flirt" as the rear end swings outward while turning in the corners.

During a pit stop, one of the crewmen will sometimes add or subtract spring pressure by attaching a ratchet and manually rotating it one way or the other. This tightens or loosens the spring and brings the frame and trailing arm forward or away from each other, applying more or less pressure on the tire when the car goes into a turn. This is known as adding or subtracting wedge.

1. Ratchet inserted by crewman
2. Side window
3. Ratchet extension
4. Rear window
5. Screw jack
6. Chassis frame
7. Coil spring
8. Trailing arm
9. Trailing arm end
10. Goodyear Tire

**Oversteer/Loose**

**Understeer/Tight**
Tight vs. Loose Conditions and Adjustments

Tight: Also known as understeer. This occurs when the front wheels lose traction before the rear wheels. It causes the stock car to have trouble steering sharply and smoothly through the turns as the front end pushes toward the wall.

Loose: Also known as oversteer. This occurs when the rear tires of the stock car have trouble sticking in the corners. This causes the car to "fishtail" as the rear end swings outward while turning in the corners.