

CENTRE : DDU KAUSHAL KENDRA

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COURSE NAME : AUTOMOTIVE TRANSMISSION SYSTEM

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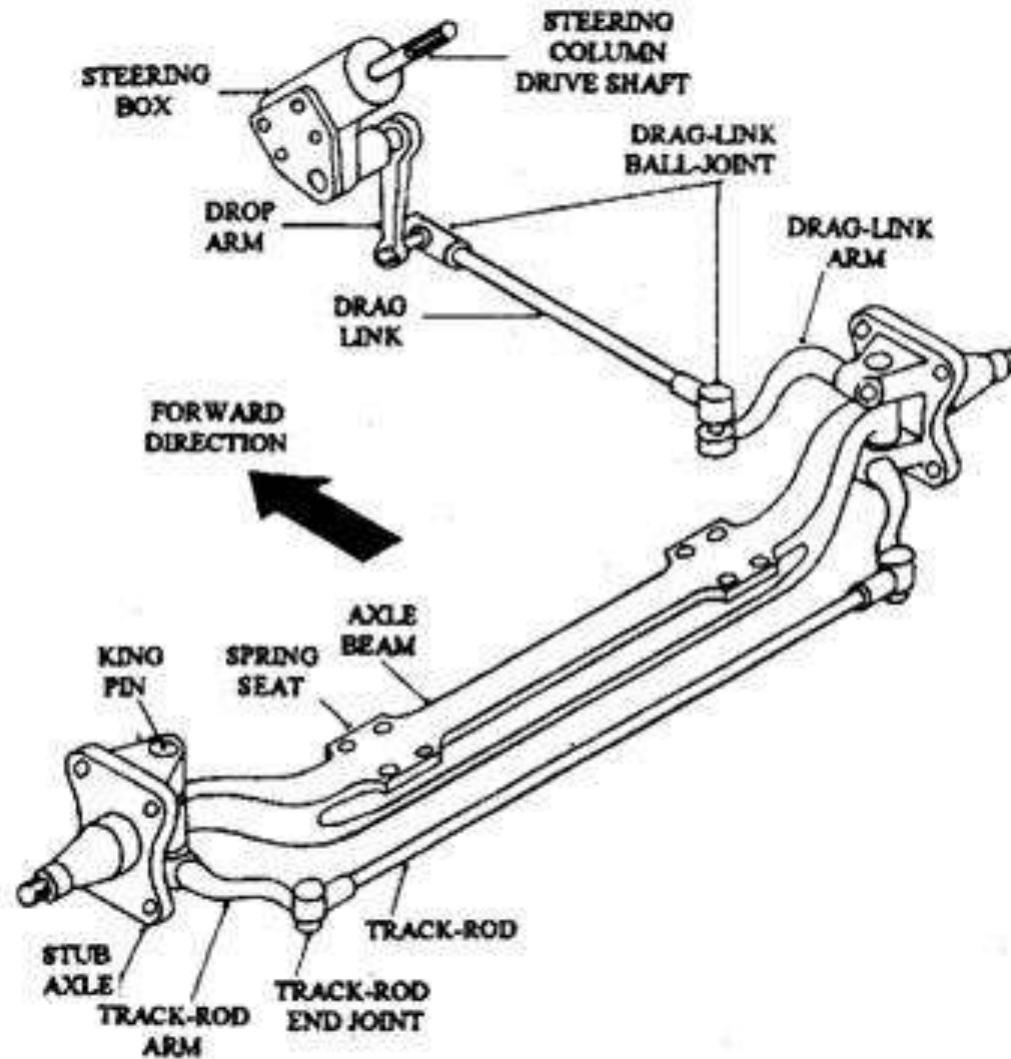
DESIGNATION : GUEST FACULTY

TOPIC : STEERING SYSTEM

STEERING SYSTEM

- **Steering** is the term applied to the collection of components, linkages, etc. which will allow a vehicle to follow the desired course.
- An automobile is steered with the help of steering gears and linkages, which transfer the motion of the hand operated steering wheel to the pivoted front wheel hubs via steering column. The other parts that are used for steering a vehicle are steering wheel pads, steering shafts, steering boxes, steering arms and steering stabilizers. These parts are made of durable materials like stainless steel, iron, aluminum, copper, magnesium, titanium, platinum, rubber, and plastics.

COMPONENTS OF A CONVENTIONAL STEERING SYSTEM



FUNCTIONS OF STEERING SYSTEMS

- It helps in swinging the wheels to the left or right.
- It converts the rotary movement of the steering wheel into an angular turn of the front wheels.
- It multiplies the effort of the driver by leverage in order to make it fairly easy to turn the wheels.
- It absorbs a major part of the road shocks thereby preventing them to get transmitted to the hands of the driver

FUNCTIONS OF STEERING SYSTEM contd.

- It helps in turning the vehicle at the will of the driver.
- It provides directional stability.
- It helps in controlling wear and tear of tyres.
- It helps in achieving the self-righting effect.

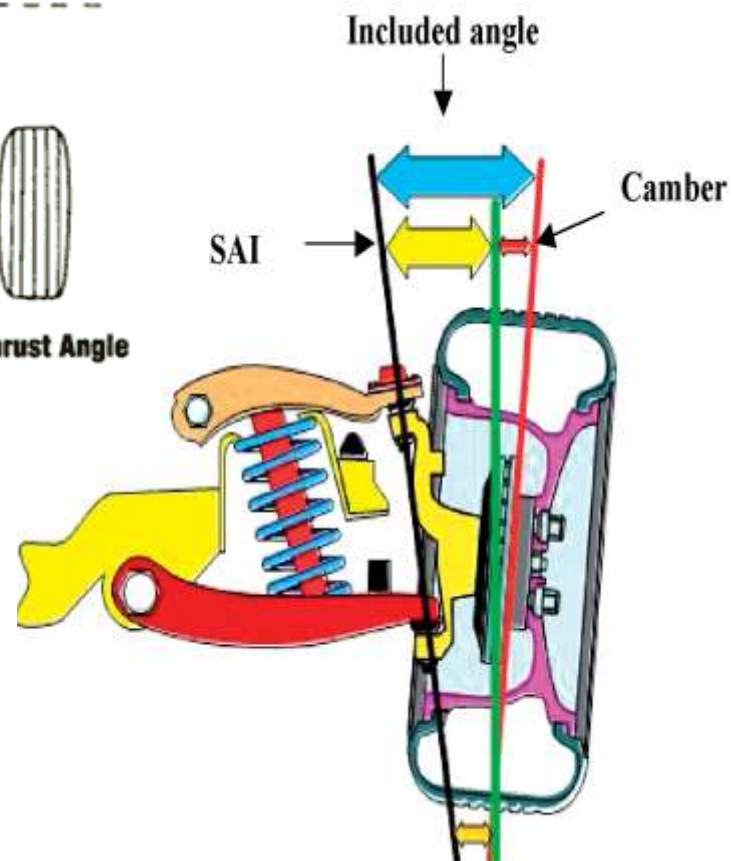
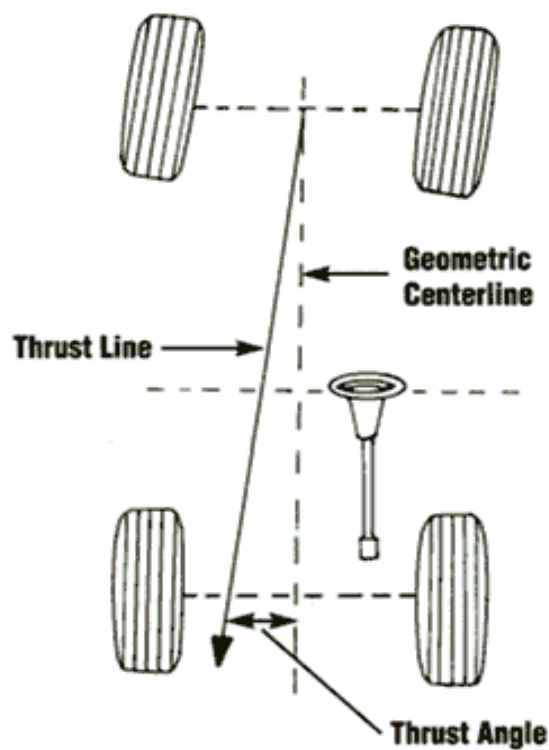
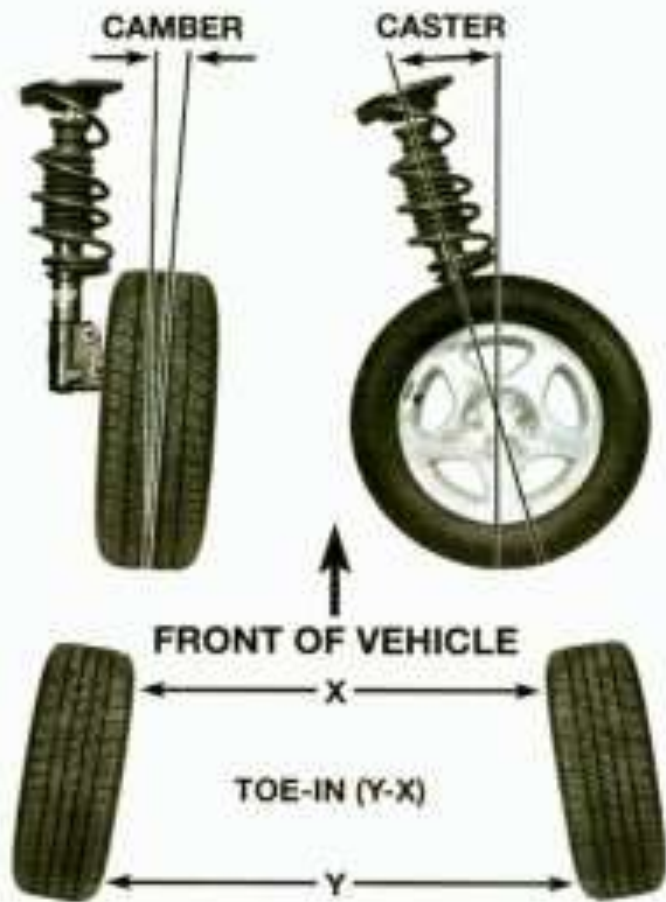
REQUIREMENTS OF STEERING SYSTEM

The steering system of any vehicle should fulfill the following requirements:

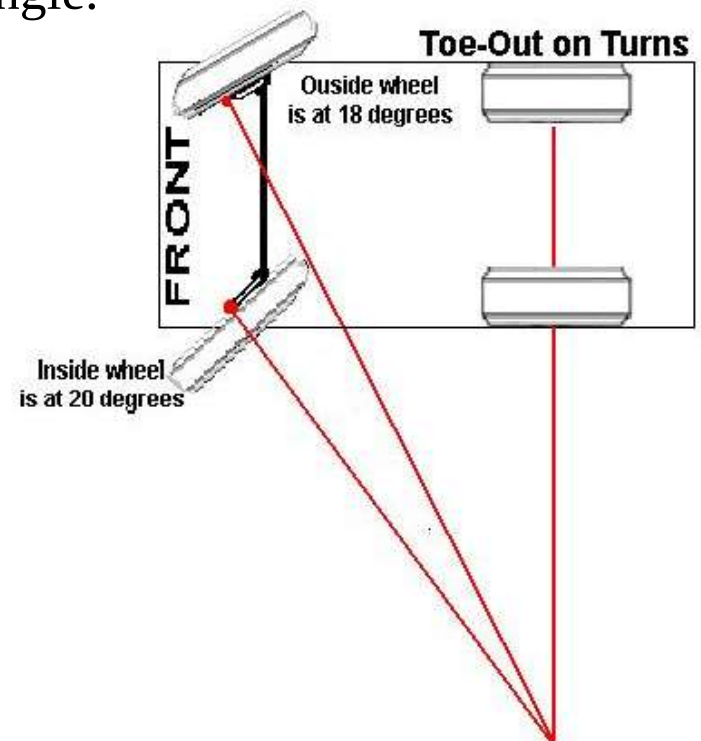
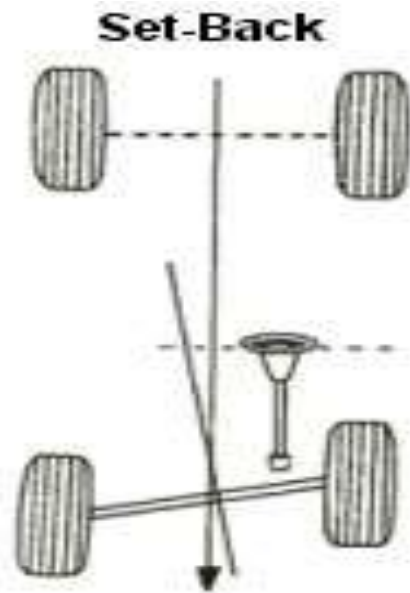
- It should multiply the turning effort applied on the steering wheel by the driver.
- It should be to a certain extent irreversible. In other words, the shocks of the road surface encountered by the wheels should not be transmitted to the driver's hands.
- The mechanism should have self rightening effect i.e., when the driver releases the steering wheel after negotiating the turn, the wheel should try to achieve straight ahead position.

STEERING GEOMETRY

- The term "*steering geometry*" (also known as "front-end geometry") refers to the angular Relationship between suspension and steering parts, front wheels, and the road surface. Because alignment deals with angles and affects steering, the method of describing alignment measurements is called steering geometry.
- There are five steering geometry angles : Camber , Caster ,Toe, Steering axis inclination, and Toe-out on turns
- There are two more steering geometry angles that are not specific to each wheel but measure the spatial relationship among all four wheels .These are Setback and Thrust angle.



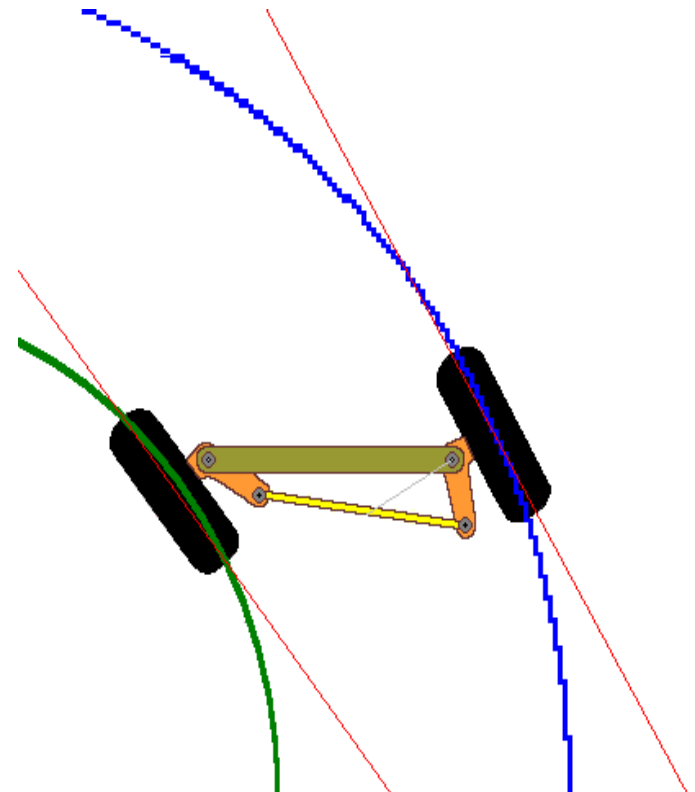
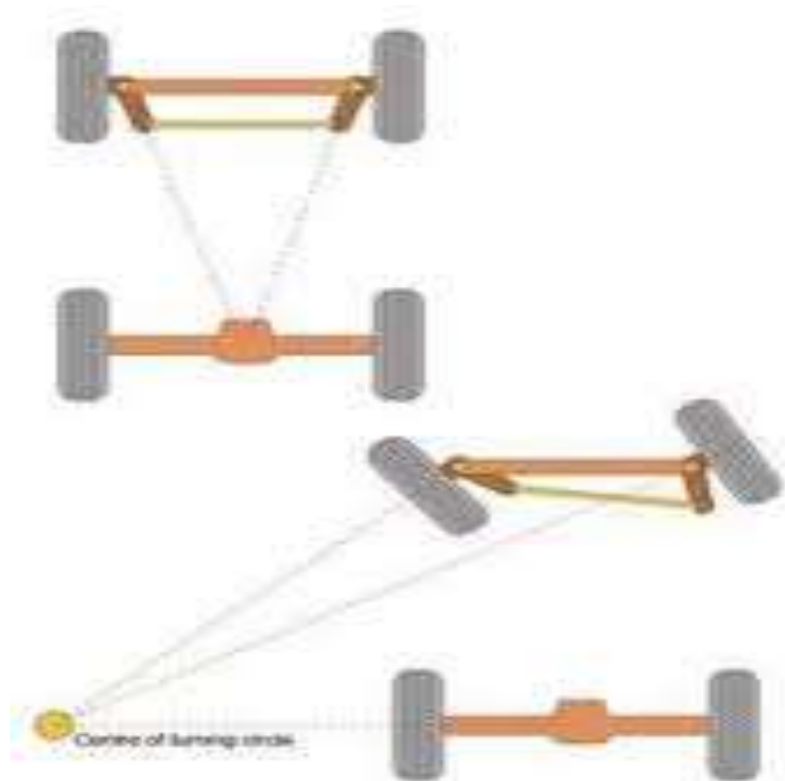
- All steering geometry angles can be measured in degrees. However, toe out and Setback can be measured in terms of distance and may be given in inches or mm.
- The 5 traditional alignment angles can be classified as tire wear angles or directional control angles. A tire wear angle helps prevent tire wear when correct and accelerates tire wear when incorrect. A directional control angle affects steering and handling. All 5 of the traditional alignment angles are directional control angles. The Thrust angle and setback hold importance for the effect they have on other alignment angles.



ACKERMANN STEERING GEOMETRY

- Ackermann steering geometry is a geometric arrangement of linkages in the steering of a car or other vehicle designed to solve the problem of wheels on the inside and outside of a turn needing to trace out circles of different radii.
- Modern cars do not use *pure Ackermann steering*, partly because it ignores important dynamic and compliant effects. Some race cars use *reverse Ackermann geometry* to compensate for the large difference in slip angle between the inner and outer front tires while cornering at high speed. The use of such geometry helps reduce tyre temperatures during high-speed cornering but compromises performance in low speed maneuvers.
- The intention of Ackermann geometry is to avoid the need for tyres to slip sideways when following the path around a curve. The geometrical solution to this is for all wheels to have their axles arranged as radii of a circle with a common centre point. As the rear wheels are fixed, this centre point must be on a line extended from the rear axle. Intersecting the axes of the front wheels on this line as well requires that the inside front wheel is turned, when steering, through a greater angle than the outside wheel

- Rather than the preceding "turntable" steering, where both front wheels turned around a common pivot, each wheel gained its own pivot, close to its own hub. A linkage between these hubs moved the two wheels together, and by careful arrangement of the linkage dimensions the Ackermann geometry could be approximated. This was achieved by making the linkage *not* a simple parallelogram, but by making the length of the track rod (the moving link between the hubs) shorter than that of the axle, so that the steering arms of the hubs appeared to "toe out". If the track rod is placed ahead of the axle, it should instead be longer in comparison thus preventing same "toe-out".



STEERING GEARS

- The steering gear is a device for converting the rotary motion of the steering wheel into straight line motion of the linkage with a mechanical advantage.
- If the steering wheel is connected directly to the steering linkage it would require a great effort to move the front wheels. Therefore, to assist the driver, a reduction system is used having a steering ratio (*the ratio between the turn of the steering wheel in degrees or handlebars and the turn of the wheels in degrees*) between 10:1 to 24:1 the actual value depending upon the type and weight of the vehicle.
- A higher steering ratio means that you have to turn the steering wheel more, to get the wheels turning, but it will be easier to turn the steering wheel. A lower steering ratio means that you have to turn the steering wheel less, to get the wheels turning, but it will be harder to turn the steering wheel. Larger and heavier vehicles like trucks will often have a higher steering ratio, which will make the steering wheel easier to turn. In normal and lighter cars, the wheels becomes easier to turn, so the steering ratio doesn't have to be as high. In race cars the ratio becomes really low, because you want the vehicle to respond a lot quicker than in normal cars.

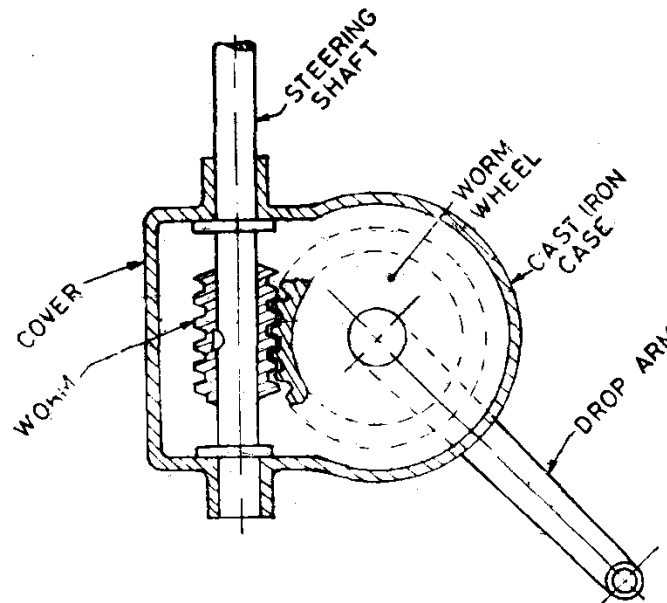
The steering gears are enclosed in a box, called the steering gear box. There are many different designs of steering gear box.

They are as follows:

- Worm and wheel steering gear
- Worm and sector steering gear
- Cam and lever / peg steering gear
- Cam and roller or worm and roller steering gear
- Worm and nut or screw and nut steering gear
- Recirculating ball steering gear
- Rack and pinion steering gear.

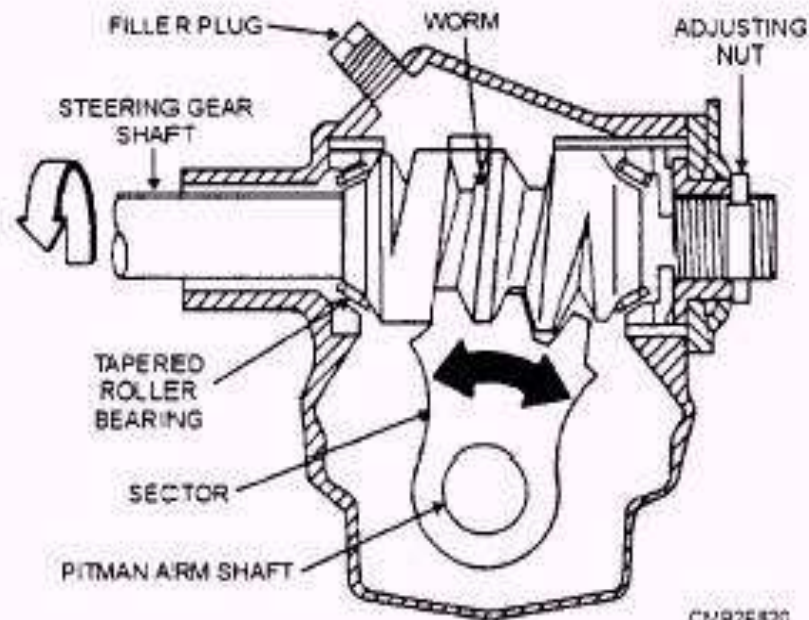
WORM AND WHEEL STEERING GEAR

- The system consists of worm wheel which is carried in bearings in a cast iron case. The case is made in halves. The outer end of the worm wheel is fixed to a drop arm which is having ball end to connect the side rod. The side rod is connected to the steering arm which is fixed to the stub axles. The worm which is keyed on to a steering shaft have a mesh with the worm wheel. The steering wheel is mounted at the upper end of the steering shaft. When driver rotates the steering wheel then drop arm moves either backward or forward direction. This motion results in motion of the stub axles.



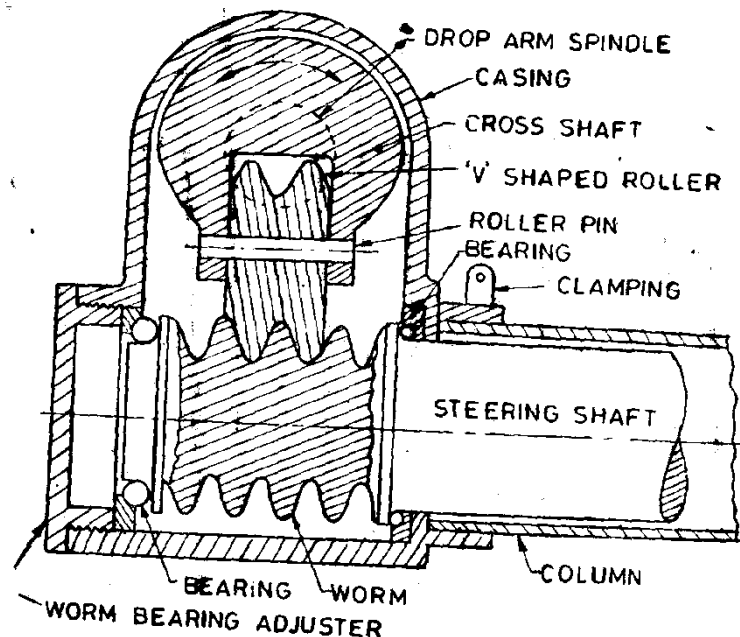
WORM AND SECTOR STEERING GEAR

- In this type of steering box, the end of the shaft from the steering wheel has a worm gear attached to it. It meshes directly with a sector gear (so called because it's a section of a full gear wheel). When the steering wheel is turned, the shaft turns the worm gear, and the sector gear pivots around its axis as its teeth are moved along the worm gear. The sector gear is mounted on the cross shaft which passes through the steering box and out the bottom where it is splined, and the pitman arm is attached to the splines. When the sector gear turns, it turns the cross shaft, which turns the pitman arm, giving the output motion that is fed into the mechanical linkage on the track rod. The box itself is sealed and filled with grease. In actual case, the worm wheel is not essential as it is having only partial rotation. Hence in this type only a sector of wheel is used instead of worm wheel.



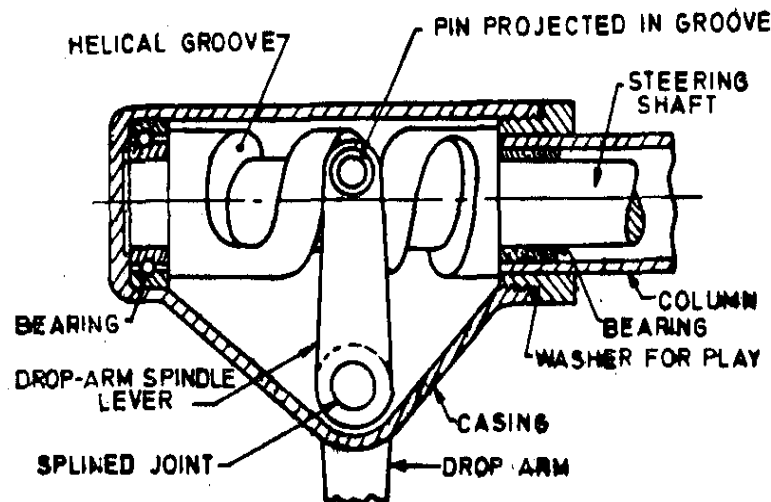
WORM AND ROLLER STEERING GEAR

- Here a two toothed roller is fastened to the cross-shaft so that it meshes with the threads of the worm gear. The worm gear is formed on the bottom end of the steering wheel shaft. Worm is fastened between the two ball bearings in the casing. The outer end of the cross-shaft is formed in the spindle to fix the drop arm. When the worm gear is turned by the steering wheel shaft, it causes the roller to move in an arc so as to rotate the cross-shaft and at the same time turn on the roller pin connecting it to the cross-shaft. The casing of the system is fixed with the column and generally bolted to the frame. Similarly there can be other design of steering gears which may use one or three-tooth rollers .



CAM AND LEVER/ PEG STEERING GEAR

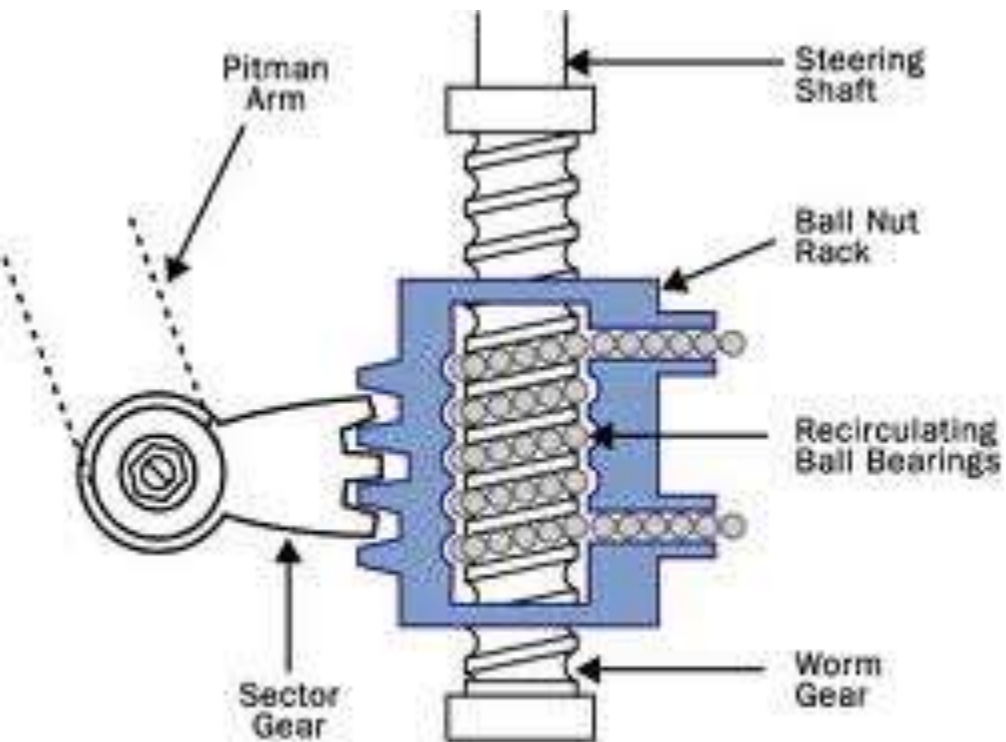
- Here a helical groove is formed at the bottom end of the steering wheel shaft. The helical groove engages the projected pin of the drop arm spindle lever. The drop-arm is made rigid with the lever/peg by a splined spindle.
- The to and fro motion is obtained at the drop-arm when the steering wheel shaft is turned. This motion results the turning of the stub axles. The end play of the steering wheel shaft can be adjusted by putting a suitable washer at the lock nut. The meshing of the projected pin in helical groove is also adjusted by a screw provided at the end of the lever spindle. In the recent models, the projected pin is made in the form of a roller. The projected pin may be one or two in number, accordingly they are referred as cam and single lever or double lever steering gear mechanism



RECIRCULATING BALL TYPE STEERING GEAR

- It consists of a worm at the end of steering rod. A nut is mounted on the worm with two sets of balls in the grooves of the worm, in between the nut and the worm. The balls reduce the friction during the movement of the nut on the worm. The nut has a number of teeth on outside, which mesh with the teeth on a worm wheel sector, on which is further mounted the drop arm.
- When the steering wheel is turned, the balls in the worm roll in the grooves and cause the nut to travel along the length of the worm. The balls, which are in 2 sets, are recirculated through the guides. The movement of the nut causes the wheel sector to turn at an angle and actuate the link rod through the drop arm, resulting in the desired steering of the wheels. The end play of the worm can be adjusted by means of the adjuster nut provided.
- To compensate for the wear of the teeth on the nut and the worm, the two have to be brought nearer bodily. To achieve this, the teeth on the nut are made tapered in the plane perpendicular to the plane of Figure.

RECIRCULATING BALL TYPE STEERING GEAR



RACK-AND-PINION STEERING

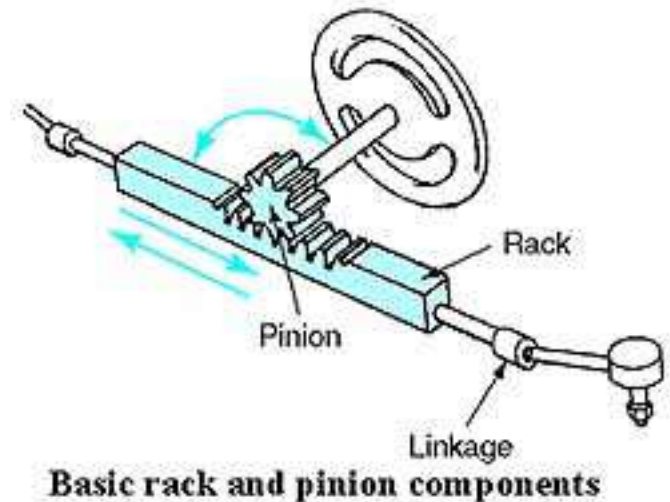
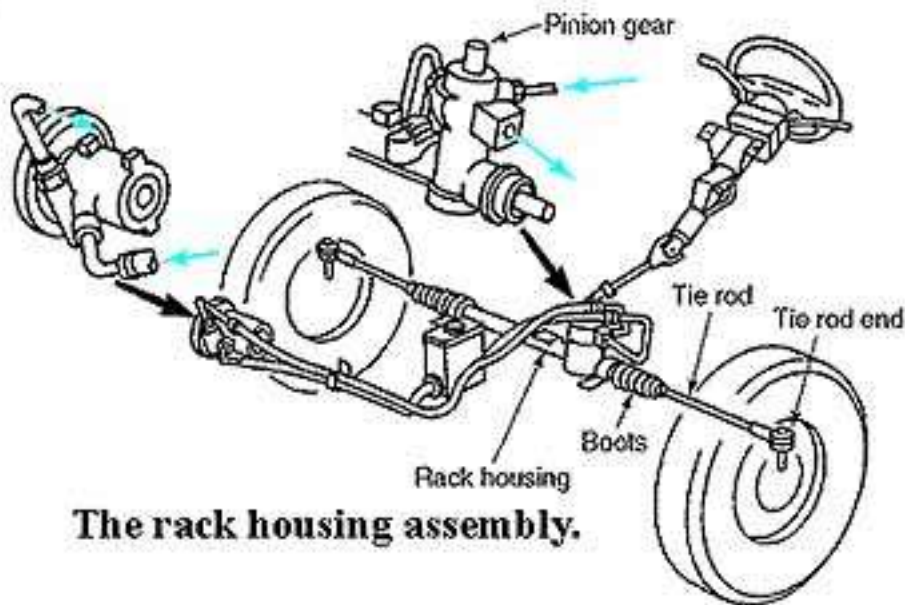
- Rack-and-pinion steering is quickly becoming the most common type of steering on cars, small trucks and SUVs. On most cars, it takes three to four complete revolutions of the steering wheel to make the wheels turn from lock to lock (from far left to far right).

The rack-and-pinion gear set does two things:

- It converts the rotational motion of the steering wheel into the linear motion needed to turn the wheels.
 - It provides a gear reduction, making it easier to turn the wheels.
- A rack-and-pinion gear set is enclosed in a metal tube, with each end of the rack protruding from the tube. A rod, called a tie rod, connects to each end of the rack. The pinion gear is attached to the steering shaft. When you turn the steering wheel, the gear spins, moving the rack. The tie rod at each end of the rack connects to the steering arm on the spindle.

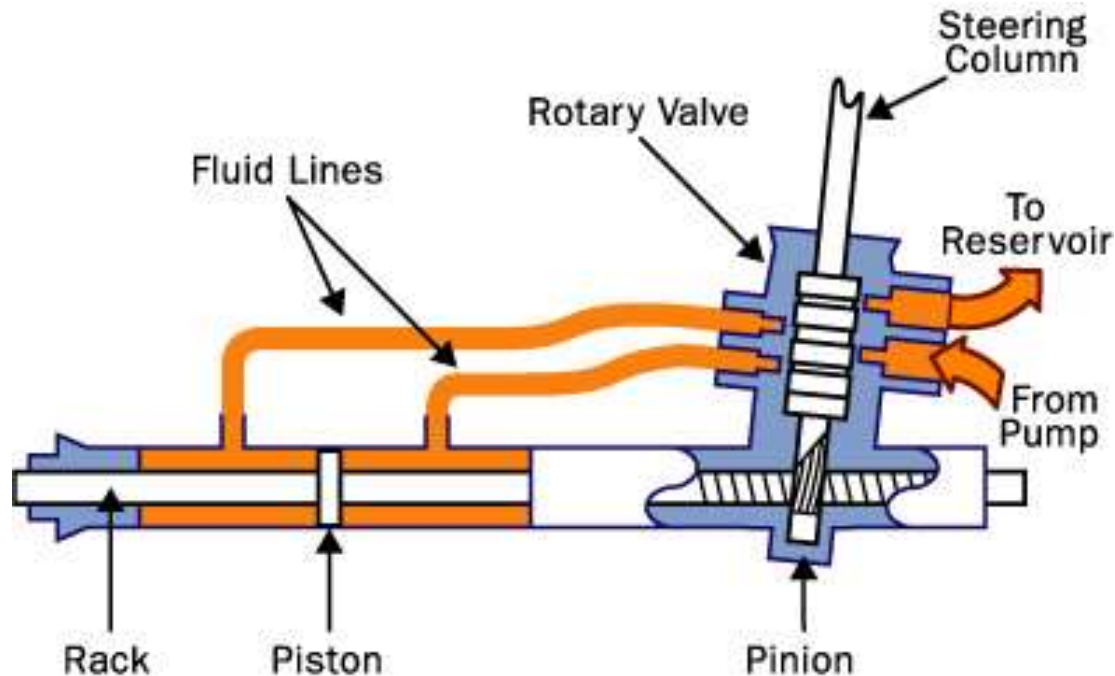
RACK-AND-PINION STEERING

- Some cars have variable-ratio steering, which uses a rack-and-pinion gear set that has a different tooth pitch (number of teeth per inch) in the center than it has on the outside. This makes the car respond quickly when starting a turn (the rack is near the center), and also reduces effort near the wheel's turning limits



Power Rack-and-pinion

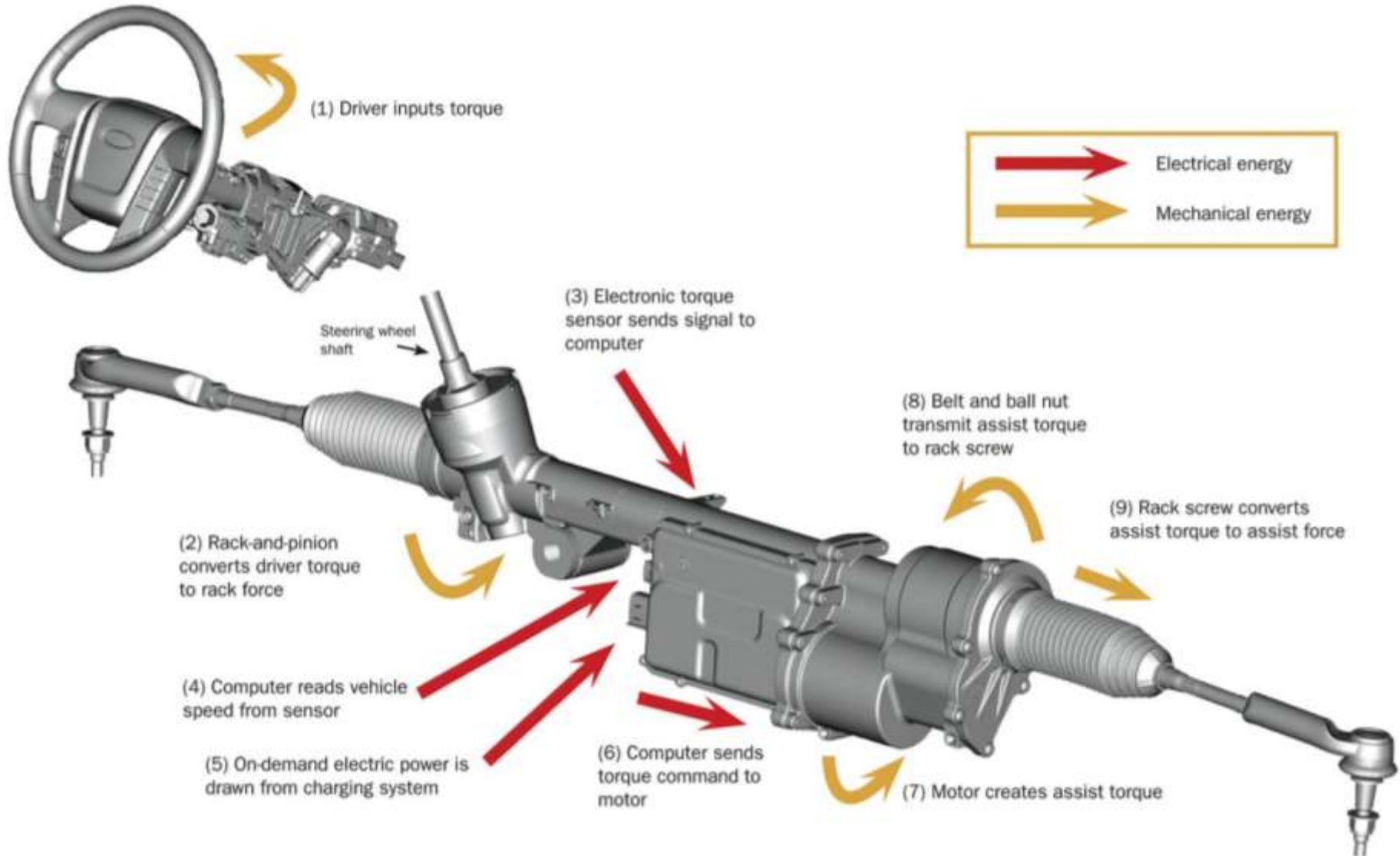
- When the rack-and-pinion is in a power-steering system, the rack has a slightly different design. Part of the rack contains a cylinder with a piston in the middle. The piston is connected to the rack. There are two fluid ports, one on either side of the piston. Supplying higher-pressure fluid to one side of the piston forces the piston to move which in turn moves the rack so providing power assist.



POWER STEERING

- Power steering has two types of device for steering effort one type is a hydraulic device utilizing engine power. The other type utilizes an electric motor. For the former, the engine is used to drive a pump. For the latter, an independent electric motor in the front luggage compartment is used the pump. Both develop fluid pressure, and this pressure acts on a piston within the power cylinder so that the pinion assists the rack effort. The amount of this assistance depends on the extent of pressure acting on the piston. Therefore, if more steering force is required, the pressure must be raised. The variation in the fluid pressure is accomplished by a control valve which is linked to the steering main shaft.
- **ELECTRIC POWER STEERING (EPS OR EPAS)** is designed to use an electric motor to reduce effort by providing steering assist to the driver of a vehicle. Sensors detect the motion and torque of the steering column, and a computer module applies assistive torque via an electric motor coupled directly to either the steering gear or steering column. This allows varying amounts of assistance to be applied depending on driving conditions. The system allows engineers to tailor steering-gear response to variable-rate and variable-damping suspension systems achieving an ideal blend of ride, handling, and steering for each vehicle. In the event of component failure, a mechanical linkage such as a rack and pinion serves as a back-up in a manner similar to that of hydraulic systems.

ELECTRIC POWER STEERING



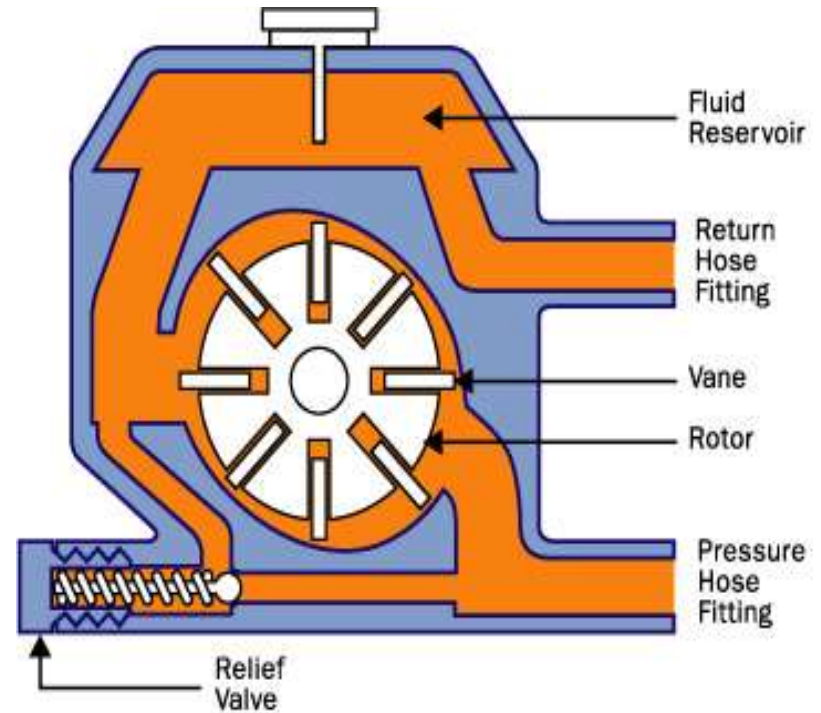
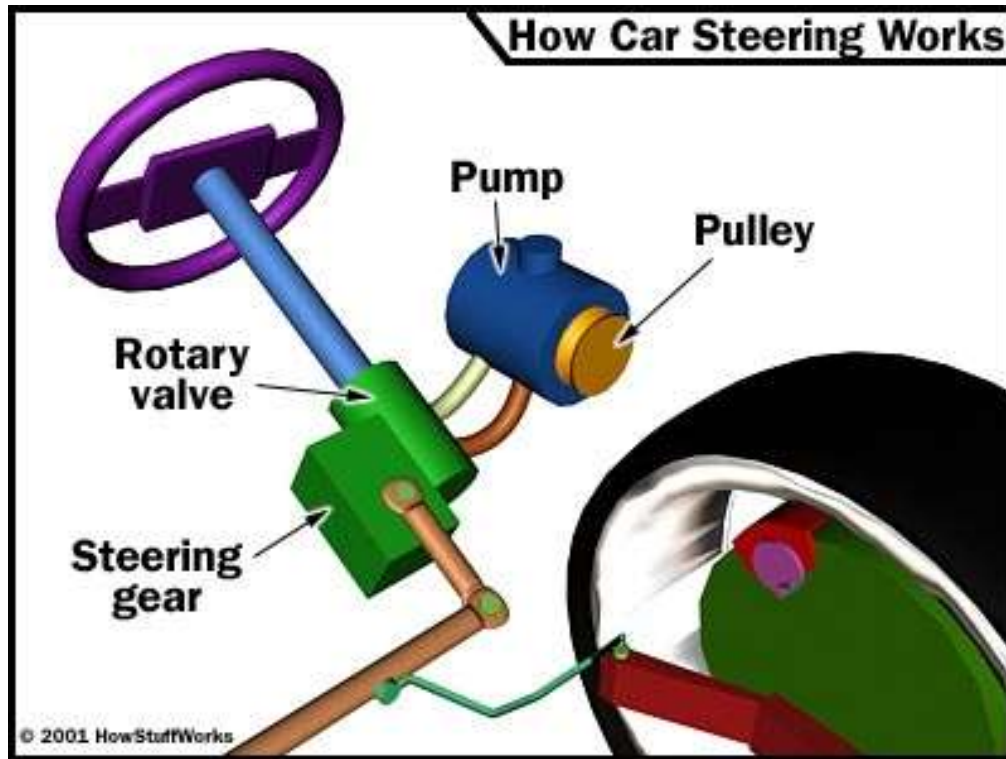
- **HYDRAULIC POWER STEERING (HPS)** is a hydraulic system for reducing the steering effort on vehicles by using hydraulic pressure to assist in turning the wheels. It is intended to provide for easier driving direction control of the car while preserving "feedback", stability and unambiguity of the trajectory specified. The steering booster is arranged so that should the booster fail, the steering will continue to work (although the wheel will feel heavier).

The steering booster consists of the following basic elements:

- Steer torque detector
- Controlled pressure distributor case
- Hydraulic booster pump
- Tank with a working liquid
- Connection hoses

The working liquid, also called "hydraulic fluid" or "oil", is the medium by which pressure is transmitted. Common working liquids are based on mineral oil. For pressure restriction in the pump there is a restrictive valve, which is adjusted on different cars in a range from 7 to 13 MPa.

HYDRAULIC POWER STEERING

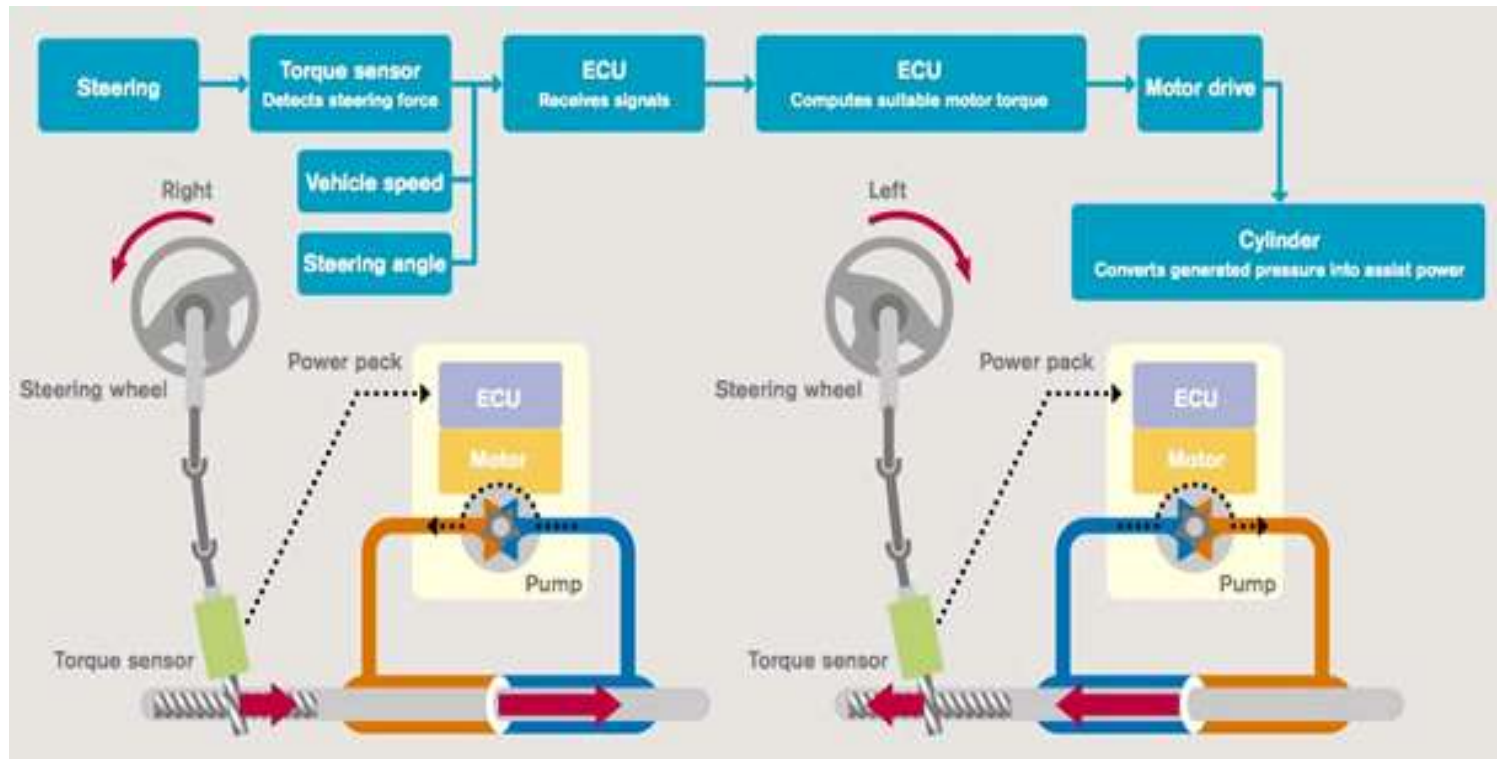


HYDRAULIC vs. ELECTRIC POWER STEERING

- Hydraulic Power Steering System is complicated compared with Electric Power Steering
- Hydraulic Power Steering System usually weighs more than Electric Power Steering
- Hydraulic Power Steering uses hydraulic fluids for operation whereas there is no such fluid needed for Electric Power Steering, thus Electric Power Steering needs less maintenance compared to hydraulic power steering.
- Electric Power Steering gives better response at different speeds as compared to Hydraulic Power Steering
- Electric Power Steering is less prone to problems and faults and are more durable as compared to Hydraulic power steering.
- Hydraulic power steering extracts power from engine, so it reduces the fuel mileage of the engine. Electric power steering consumes power from battery which is also charged by engine, but it consumes less power compared to Hydraulic power steering. So a car having Electric power steering will give more mileage than one with Hydraulic power steering.

ELECTRO-HYDRAULIC SYSTEMS

- Electro-hydraulic power steering systems, sometimes abbreviated EHPS, and also sometimes called "hybrid" systems, use the same hydraulic assist technology as standard systems, but the hydraulic pressure is provided by a pump driven by an electric motor instead of being belt-driven by the engine.
- By providing power assist via hydraulic pressure, this system delivers a naturally smooth steering feel and, thanks to the flexibility of control allowed by electric power, offers more precise steering power characteristics. It also improves fuel economy since the electric powered pump operates only when steering assist is needed

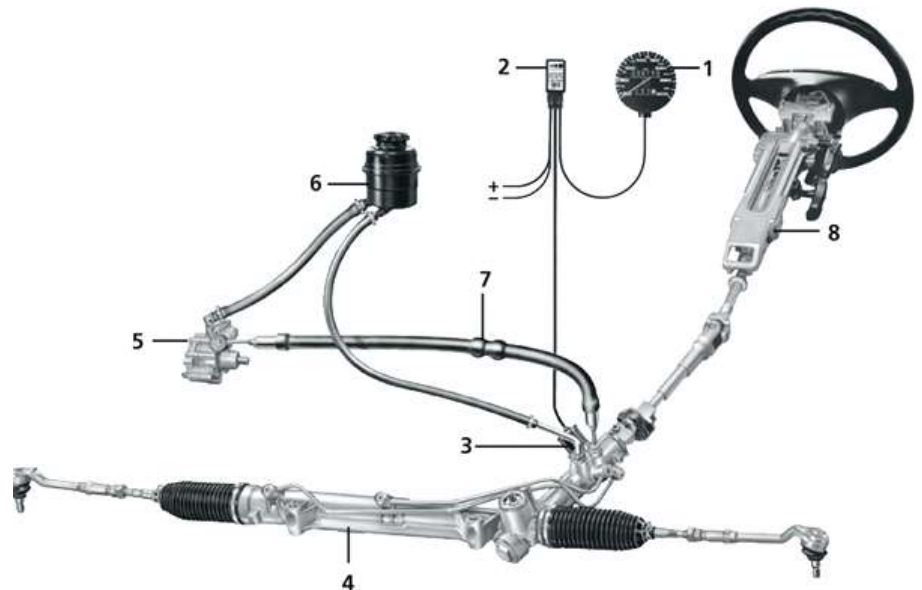


SPEED SENSITIVE STEERING

- Here the steering is heavily assisted at low speed and lightly assisted at high speed. The auto makers perceive that motorists might need to make large steering inputs while maneuvering for parking, but not while traveling at high speed. The first vehicle with this feature was the Citroën SM with its Diravi layout. Modern speed-sensitive power steering systems reduce the mechanical or electrical assistance as the vehicle speed increases, giving a more direct feel. This feature is gradually becoming more common.
- Also called Servotronic system, it offers true speed-dependent power steering where the driver can control the car even more precisely than with conventional power steering. Servotronic is used by a number of automakers, including Audi, GM, Volkswagen, BMW, Volvo and Porsche.

ZF Servotronic® 2

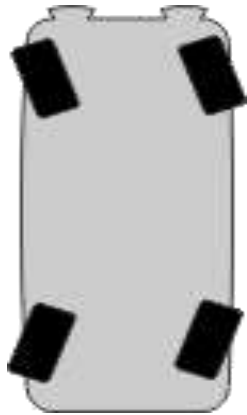
1. Electronic speedometer in the vehicle
2. Electronic control unit (ECU)
3. Electro-hydraulic transducer
4. Rack and pinion power steering gear
5. Steering pump
6. Oil reservoir with fine filter
7. Anti-vibration expansible hose
8. Manually adjustable steering column



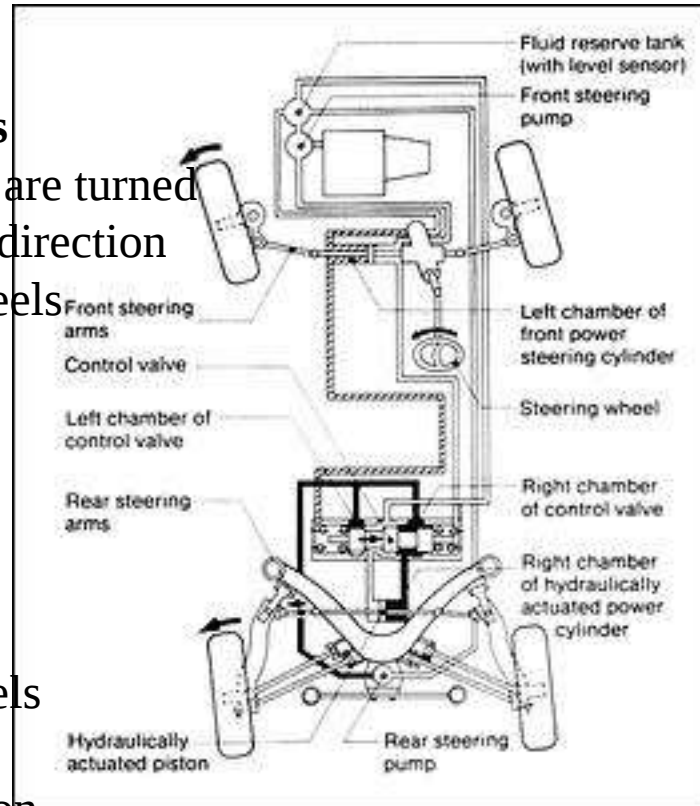
FOUR WHEEL STEERING

- Four-wheel steering (or all-wheel steering) is a system employed by some vehicles to improve steering response, increase vehicle stability while maneuvering at high speed, or to decrease turning radius at low speed.
- In most *active* four-wheel steering systems, the rear wheels are steered by a computer and actuators. The rear wheels generally cannot turn as far as the front wheels. Some systems, including *Delphi's Quadrasteer* and the system in *Honda's Prelude line*, allow the rear wheels to be steered in the opposite direction as the front wheels during low speeds. This allows the vehicle to turn in a significantly smaller radius — sometimes critical for large trucks or tractors and vehicles with trailers.
- In an active four-wheel steering system, all four wheels turn at the same time when the driver steers. There can be controls to switch off the rear steer and options to steer only the rear wheel independent of the front wheels. At slow speeds (*e.g.* parking) the rear wheels turn opposite of the front wheels, reducing the turning radius by up to twenty-five percent, while at higher speeds both front and rear wheels turn alike (electronically controlled), so that the vehicle may change position with less yaw, enhancing straight-line stability. The "Snaking effect" experienced during motorway drives while towing a travel trailer is thus largely nullified. Four-wheel steering found its most widespread use in large farm vehicles and trucks. Some of the modern European Intercity buses also utilize four-wheel steering to assist maneuverability in bus terminals, and also to improve road stability.

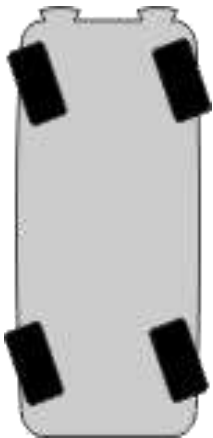
FOUR WHEEL STEERING SYSTEM



slow speeds
rear wheels are turned
in opposite direction
of front wheels



fast speeds
all four wheels
are turned in
same direction

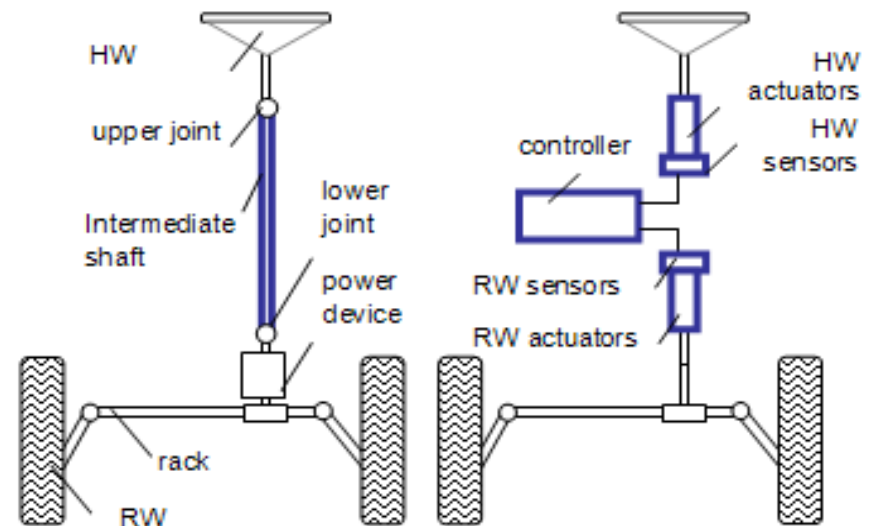


STEER-BY-WIRE SYSTEMS

The aim of *steer-by-wire* technology is to completely do away with as many mechanical components (steering shaft, column, gear reduction mechanism, etc.) as possible. Completely replacing conventional steering system with steer-by-wire holds several advantages, such as:

- The absence of steering column simplifies the car interior design.
- The absence of steering shaft, column and gear reduction mechanism allows much better space utilization in the engine compartment.
- The steering mechanism can be designed and installed as a modular unit.
- Without mechanical connection between the steering wheel and the road wheel, it is less likely that the impact of a frontal crash will force the steering wheel to intrude into the driver's survival space.
- Steering system characteristics can easily and infinitely be adjusted to optimize the steering response and feel.

- Because of the complexity of drive-by-wire systems, some people worry about potential electronic malfunctions in sensors and computers, leading to vehicle damage or even car accidents and passenger injury.
- One argument against Steer-by-wire is that any system using software has the ability to fail regardless of how many times that software has been tested. In any case, most people refer to the saying that any software is only as good as the programmers and manufacturers who built and designed it. Because of the reliability of fly-by-wire in airplanes, it's likely that experience and product testing could bring more drive-by-wire systems safely to everyday cars. Several car companies are already using (or have used) various drive-by-wire systems in use their vehicles, including BMW, Mercedes-Benz, Land Rover, Toyota, GM, Volkswagen and Nissan.



Conversion from conventional steering system to SBW

THE END