Introduction to Steering Systems
Course Objectives

On completion of this course you will be expected to effectively:

• Identify and understand the fundamental principles of steering system
• Identify and understand the main components used in the manual steering system
• Identify and understand the different steering gear systems used
• Identify and understand the operating principles of hydraulic power assisted steering
• Identify and understand the components used in hydraulic power assisted steering
• Identify and understand the operating principles and benefits of electro/hydraulic power assisted steering
• Identify and understand the benefits of active and passive steering/suspension systems
• Identify and understand the importance of inspection and maintenance of the steering system
The steering system of a vehicle allows the driver to control the direction of the vehicle through a system of gears and linkages that connects the steering wheel with the front wheels.

The steering system must perform these functions:

• Change direction of vehicle
• Provide a degree of 'feel' of the road for the driver
• Not transmit excessive shock back to the driver due to an uneven road
• Not cause excessive tyre wear

Early vehicles used manual steering linkage system, manual steering boxes or manual racks.

Later systems used the benefits of hydraulic fluid systems to greatly improve the steering performance.

Today, we now have fully electronically controlled steering systems for greater and smoother performance and maneuverability.
Steering Systems - Introduction

When turning a corner, the driver turns a steering wheel.

This turning motion is transferred to the front road wheels.

The direction the front wheels point is the direction the car will travel, so long as the wheels do not lose grip.
The main purpose of the steering wheel is to provide the driver with a suitable amount of leverage to turn the steering from side to side with a minimal amount of effort.

Early designs of steering wheels were primitive in design and only normally had a horn button mounted in the centre hub of the wheel.

With the development of safety restraints and additional driver functionalities for audio control and cruise control.

The steering wheel has become a very sophisticated and multi-functional assembly.

With an restraints air bag mounted in the centre hub of the wheel to protect the driver in frontal and severe impacts and a series of multi-functional buttons to enable the driver to operate a multitude of systems without their hands leaving the steering wheel.
The steering column is a device intended primarily for connecting the steering wheel to the steering mechanism and allows the transfer of the driver's input torque from the steering wheel.

In addition to this, the steering column provides a suitable location for multi-functional switches either side of the steering wheel.

A location for a steering lock to secure the steering in a parked position.
Steering Systems - Steering Column

Steering Column - Upper Section

Also the column can have manual or electronic adjustment which allows the driver to adjust the height and length of the column to their preferred comfort position.

- Tilting the column adjusts the angle of the steering wheel
- Sliding the column in and out adjusts the reach (the distance of the steering wheel to the driver)
Steering Systems - Steering Column

Steering Column - Collapsible

As for the drivers protection when confronted with a frontal collision.

Most modern vehicles use a collapsible or energy absorbing steering column.

During a frontal impact, the steering column compresses.

This reduces movement toward the rear of the vehicle where it would impact with the driver.

The column also absorbs any force generated if the driver’s body impacts on the steering wheel.

This design, along side the drivers steering wheel air bag provides the driver with added protection.
Steering Systems - Steering Column

Steering Column - Collapsible

There are three main types of collapsible steering column:
Steering Systems - Steering Column

Steering Column - Lower Section

The lower section of the steering column is designed to absorb road wheel shock when driving with using rubber couplings.

Also the lower column will have a universal joint located in the upper and lower sections.

This is to allow for the different relationship between steering rack and column, when manoeuvring from lock to lock, as well as allowing the rack to move on impact.

Within the upper section of the assembly there will be a compression joint that is designed to collapse on impact.
Steering Systems - Steering Column

Steering Column - Lower Section

Universal joints allow the steering shaft to change angles. Most steering columns are designed with a collapsible section that helps prevent the forces generated in an accident from being transferred to the driver.

The bottom of the steering shaft connects to the steering components (rack or box).
The steering gearbox provides the driver with a lever system to enable them to exert a large force at the road wheel with the minimum effort, and to control the direction of vehicle motion accurately.

The overall ratio between the steering wheel and the road wheel varies from about 18 : 1 to 35 : 1, depending on the load on the road wheels and the type of steering.
As the ratio is raised, a large number of turns are required to move the wheel from lock to lock.

This makes it difficult to make a rapid change in vehicle direction.

By varying the efficiency, the degree of reversibility (a reversible gear transmits motion from steering wheel to drop arm and vice versa) can be controlled.

This then enable the driver to ‘feel’ the wheels, yet not be subjected to major road shocks.
A number of different types of steering gear systems have been used over the years.

They are classified into two groups. They are as follows:

- Steering box types
- Rack-and-pinion types
Steering Systems - Layouts

Steering Box

Sometime identified as the linkage steering

The steering column shaft is coupled through a steering gearbox to a ‘Pitman arm’ that moves to drive the centre link and wheels, guided by the idler arms.
Rack & Pinion Steering

Compare this with rack and pinion steering layout, where a pinion wheel turns on a toothed rack to move a steering bar horizontally.
The steering box is commonly used in larger vehicles, such as commercial-type vehicles.

Although some manufacturers of four-wheel drive vehicles use this system due to its strength.

There are a number of different types of steering box used, which include:

- Worm and Sector
- Screw and Nut
- Recirculating Ball
- Cam and Peg
- Worm and Roller

All of the steering box named above are identified by their internal mechanical design.

All of them operate by either their mechanical structure or are supported by the means of a hydraulic fluid system to enhance their performance.
The steering box converts rotation of the steering shaft into angular movement of the ‘Pitman arm’.

The box is partially filled with oil to lubricate the steering mechanism inside.

The steering shaft turns a worm shaft that runs through a threaded nut.

The nut has teeth that engage with the teeth on a sector 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 oil or grease.
As the driver turning the steering wheel it makes the worm shaft turn.

The worm shaft acts as a screw, and the nut rides up and down as the screw turns.

This in turn rotates the sector gear shaft, because the teeth on the nut are meshed with the teeth on the sector gear.
The screw and nut type mechanism is possibly the basic form for all the other types of steering gear box mechanisms.

A nut is screwed on a multi-start thread formed on the inner column.

This design gives much more strength to the main shaft.

When the steering wheel is turned, the splined end rotates causing the thread section to rotate too, but because the nut is prevented from turning the ball joint has to move up and down with the thread instead.

This movement then causes the rocker shaft to eventually transmit movement to the steering linkage and onto the road wheels.
In a recirculating ball steering box, the worm drive has many more turns on it with a finer pitch.

A box or nut is clamped over the worm drive that contains dozens of ball bearings.

These loop around the worm drive and then out into a recirculating channel within the nut where they are fed back into the worm drive again.
Steering Systems - Recirculating Ball Steering Box

This system has much less free play or slack in it than the other designs, hence why it's used the most.

The example shows the mechanism with the nut shown in cutaway, so you can see the ball bearings and the recirculation channel.
As the steering wheel is turned, the worm drive turns and forces the ball bearings to press against the channel inside the nut.

This forces the nut to move along the worm drive.

The nut itself has a couple of gear teeth cast into the outside of it and these mesh with the teeth on a sector gear which is attached to the cross shaft just like in the worm and sector mechanism.
Worm Gear Adjuster

The adjuster sets the pre-load on the thrust bearings that locates the worm shaft.

The sector gear shaft has ball or roller bearings to reduce friction.

Worm gear preload is needed to prevent free play in the steering that would allow the vehicle to wander.

The lubricant for the steering gear is kept in place with seals.
A tapered peg in the rocker arm engages with a special cam formed on the inner column.

The end-float of the column is controlled by shims, and an adjusting screw on the side cover governs the backlash and end-float of the rocker shaft.

A modified form, known as the high efficiency cam and peg gear, uses a peg, which is allowed to rotate in bearings in the rocker arm.
Steering Systems - Cam & Peg Ball Steering Box

- Input Shaft
- Adjuster Lock Nut
- Housing
- Side Plate
- Lock Nut
- Adjusting Screw
- Rocker Shaft
- Base Plate
- Cam
- Peg
- Lock Nut
- Output Shaft
- Pitman Arm (Drop Arm)
- Filler Plug
- Lock Nut
- Adjusting Screw
- Lock Nut
Steering Systems - Worm & Roller Steering Box

The worm and roller steering box is similar in design to the worm and sector box.

The difference here is that instead of having a sector gear that meshes with the worm gear, there is a roller instead.

The roller is mounted on a roller bearing shaft and is held captive on the end of the cross shaft.
As the worm gear turns, the roller is forced to move along it but because it is held captive on the cross shaft, it twists the cross shaft.

Typically in these designs, the worm gear is actually an hourglass shape so that it is wider at the ends.

Without the hourglass shape, the roller might disengage from it at the extents of its travel.
Rack-and-pinion steering systems are the most common type of steering found on modern cars and small commercial vehicles.

Rack-and-pinion steering is more precise and compact than conventional steering systems, mainly due to the fact it uses fewer component parts and has a more direct path to the wheels.

The rack is contained in a metal housing and bolted to the vehicle body frame or sub-frame using either U-shaped brackets or bolt-through brackets on the housing.
Steering Systems - Rack & Pinion Steering

At the base of the steering column there is a short pinion shaft (gear wheel) located within the steering rack housing.

The pinion gear teeth mesh with a series of teeth that are located on a long shaft which is located longitudinally within the housing and is known as the rack.
Steering Systems - Rack & Pinion Steering

Moving the steering wheel from side to side rotates the pinion shaft and in turn moves the rack shaft.

Changing a rotary motion of the pinion gear into linear motion of the rack.

The pinion gear meshes very closely to the teeth of the rack.

This helps minimise any backlash within the gear mechanism, minimises any wear and provides the driver with very precise steering feel.
The rack needs to be held close to the pinion to provide a good meshing of gears, but not so tightly that the gears bind.

A yoke bushing is used to support the rack, under pressure from a spring.

Shims can be added or removed to tighten or relax the yoke bushing against the rack.
Some manufacturers use an adjuster plug, rather than shims, to force the spring and therefore the yoke bushing, against the rack.

Manufacturers set this according to specifications to control steering harshness, noise and feedback.

This adjustment is called the rack preload or yoke lash.
The track rod arm is the component that links the main steering shaft (Rack) to the outer track rod ends on either side of the vehicle.

The arm is designed to allow for steering and suspension movement.

This is achieved by the use of a swivel joint located in the inner section of the arm.
The arm is secured to the main rack shaft by means of a threaded interlock.

At the other end of the arm you will identify that the shaft is threaded.

This is to allow the track rod end to be connected to the arm and also to allow for adjustment of the steering front toe.
Steering rack gaiters are a pleated rubber tubed design. Mounted on each side of the steering rack, they are designed to protect the steering rack inner joints and mechanism from any road dirt and water.

Secured at either end by retaining straps, they allow for steering arm movement depending on suspension and steering demands.

Rotating the steering from lock to lock the gaiters expand and retract, maintaining their position and protection of the steering inner joints and seals.
The track rod ends are located on either ends of steering rack arms and are designed to allow for angular and rotational movement of the steering and suspension.

The joints are similar in design to a ball joint but has an internal or external threaded section that when located, interlocks with the track control arms.

Early designed ball joints had a additional grease nipple located in to the base of the assembly.

Regular greasing was required to maintain and prolong the service life of the joint.
On assessing the design at the ball joint end, the joint has a tapered and threaded pin shaft/pin at one end and a ball shaped knuckle at the other end.

The knuckle joint end is located within a plastic, spring-loaded seat.

In-cased within the metal housing and protected by a plastic bush located on the top of the joint and sealed with a rubber dust cover and retaining ring.

The ball knuckle joint is made from heat-treated steel to give strength and a clean finish.

Angular Movement (Possible each side of centre)
The rubber dust cover is designed to keep out any dirt or moisture also retains the pre-packed grease within the joint housing.

The joint is pre-packed and seal for its life.

At the other end of the joint is the end that connects to the track control arm.

Depending on design determines the fitment to the track arm.

Securing the joint to the arm would be achieved by a lock-nut that secures the joint to the shaft.

At the ball joint end, the joint is secured to the hub steering arm by a nylon lock-nut or a castle-nut and split pin.
To adjust the vehicles steering toe angle and to align the steering wheel, the track rod ends are adjusted equally to their required position and secured in place.

This is just one of a number of adjustment procedures that must be accurately set up if the vehicle is to steer correctly and minimise any abnormal tyre wear.
Steering Systems - Hub Carrier Assembly

The hub carrier assembly transfers movement of the steering rack, via the track rods, into a change of wheel angle.

The hub assembly is the central link to connect up the steering to the suspension.

To enable the suspension to have suitable movement but with sustainable strength, the upper section of the hub is normally mounted to the suspension leg which houses the coil spring and shock absorber.
The lower section of the hub is then connected via the lower ball joint which is normally part of the lower suspension arm.

The hub carrier assembly also supports the brake disc, caliper and the road wheel via a centralised wheel bearing and hub flange.
On a linkage type steering system layout where it utilizes the usage of a steering box, there are some additional components used:

- Idler Arm
- Bracket
- Track Rod
- Sleeve Adjuster
- Centre Link
- Idler Arm
- Pitman Arm
- Track Rod
- Sleeve Adjuster

Steering Systems - Linkage Type Steering
Movement from the steering box is coupled and transmitted through to a steering arm known as a ‘Pitman arm’ which in turn then moves to drive the centre link (drag link) and wheels, guided by an idler arm.
Steering Systems - Pitman Arm

With using a Pitman arm within the linkage type steering system, usually uses a worm drive on the steering shaft.

A Pitman arm transforms the rotary movement into a horizontal movement at the linkages.

Only a small number of teeth are needed on the Pitman arm cog wheel.

The practical type shown in this diagram uses a re-circulating ball bearing mechanism.
An idler arm keeps the steering centre link parallel to the front axle and prevents any unwanted flexing of steering component parts.

One end is attached to the vehicle frame and the other end to the centre link (drag link).

The idler arm operates in tandem with the Pitman arm.

The idler can also act as a damper but does not affect the overall steering movement.
The centre link is known by several names, for example, relay rod, track bar and more commonly known as the drag link.

The centre link is used to transmit the steering motion from the Pitman arm to the inner track rods on each side of the vehicle.

The centre link or drag link can be designed with either ball joints or without.
Some vehicles have a hydraulic damper installed between the centre link and the frame or axle.

The damper absorbs road shocks in the steering system and prevents steering wobble at higher road speeds.

A hydraulic piston inside allows small amounts of hydraulic fluid to pass through calibrated holes to absorb shock energy.
The track rod assembly contains an adjuster sleeve with internal left hand and right hand threads.

At each end of the assembly is a track rod ball joint.
Power Assisted Steering (PAS) is now common on most vehicles today.

This has been a major advancement from the early design of manual steering.

Both, steering racks and boxes utilise the benefits of this assistance.

Some advantages of Power Assisted Steering (PAS) are as follows:

• Minimise driver fatigue by lightening the action of the steering. This is more evident during parking manoeuvres when the resistance to turning the steered wheels is greatest.
• Reduce the required number of turns lock to lock (the gear ratio can be higher than on manual steering).
• Reduce 'kick back' at the steering wheel by counteracting road shocks
• Improve safety by better resisting any sudden swerving of the vehicle during tyre deflation
• Permit heavier loading of the steered wheels to allow greater freedom in the overall vehicle design for optimum passenger and cargo space
At the heart of many PAS systems is a hydraulic servo-mechanism.

This operates whenever the resistance to turning the steering wheel exceeds a predetermined amount.

It then gives additional effort to assist the manual operation of the steering and so reduces steering effort.
In the hydraulic system fluid is circulated around the servo mechanism’s closed circuit by an engine driven pump.

When the steering wheel is turned a hydraulic valve allows more fluid to flow to the power cylinder.

This increases the pressure and so force is applied by the pressure to either one side or the other side of the servo piston, which is connected to the steering mechanism.
The control valve is on the end of the steering column, inside the rack housing.

The fluid reservoir can be on the top of the belt-driven hydraulic pump.

The power cylinder acts directly on the rack bar within the steering rack housing.

The steering gear (typical ratio 15:1 for power steering) is on the end of the steering column.

Fluid is fed to the power cylinder via valves, lines and hoses.

Additional oil cooler to maintain the fluid operating temperature.
The power cylinder contains a piston which is connected to the rack.

The control valve supplies high pressure fluid to the appropriate side of the piston to assist the rack in turning the wheels in the required direction.

There are two fluid ports, one each side of the piston.
The pump is usually mounted on the engine, and driven by a pulley and drive belt.

Some engine driven pumps had a fluid reservoir incorporated within its housing.

Alternatively, later systems now use a combined electrically driven oil pump and reservoir which can be mounted on the bulkhead.

The operating pressure generated in a hydraulic power steering system can be up to 200 bar (3,000 psi), feeding the control valve within the rack assembly.
The most common type of power steering pump is the vane type.

The pulley or motor drives a rotor that sits eccentrically in a cavity inside the housing.

Fluid entering the pump is trapped between spring-loaded vanes and carried to the exit port.

Similar pumps can use rollers instead of spring-loaded vanes.
The reservoir can either be built-in to the pump, or remotely mounted via a pipe.
There are three different types of control valves used within a power assisted rack and pinion or steering box assembly.

They are as follows:

- Rotary valve
- Spool valve
- Flapper valve

The control valves are used to direct the pressurized oil sent from the power steering pump to the power piston.

The power piston uses sealing rings to prevent any fluid leakage from the power piston itself.

When the steering wheel is in the straight-ahead position, the control valve is in the neutral position.
Power Assisted Steering - Control Valves

Rotary Valve Type

The high pressure fluid generated by the power steering pump is directed back to the reservoir, thus keeping the pressure even on each side of the power piston.

When the steering wheel is turned either to the right or left, this movement is transferred to the control valve via the torsion bar, which connects the two together.
Power Assisted Steering - Control Valves

**Rotary Valve Type**

As the torsion bar is twisted the control valves redirect the fluid flow causing power assistance.

The amount of assistance given is proportional to the amount of twisting force exerted on the torsion bar.
Power Assisted Steering - Control Valves

Rotary Valve Type

In the event of power steering pump failure, the direct connection between the steering wheel and the pinion gear via the torsion bar enables the driver to steer the vehicle.

Although the driver is able to turn the wheels, the steering will feel very heavy as no assistance is being given.
**Power Assisted Steering - Control Valves**

**Spool Valve Type**

The spool valve type control valve carries out the same operation as the rotary valve type.

It redirects the pressurised oil from the power steering pump to the correct side of the power piston.

The main difference is that the spool valve moves up and down rather than rotating like the rotary valve.

The control valve shaft and the pinion are again connected via a torsion bar, so if the power steering pump fails, steering can still be achieved.
Power Assisted Steering - Control Valves

Spool Valve Type

The spool valve is fitted inside the valve sleeve and the two are connected together via two steel balls.

The whole unit is connected to the pinion gear via two sliding pins.

As the pinion rotates the spool valve rotates in the same direction but also moves up and down by approximate 1mm.

The sleeve valve is secured to the pinion gear via a slide plate and snap ring.

This then stops the sleeve valve from moving up or down.
The power steering rack has an integral hydraulic actuator.
The control valve can direct pressurised fluid to either side of a piston.

When the steering wheel is turned, the control valve detects the steering effort and directs pressure to help push the steering rack piston along.
Flapper Valve Type

The flapper type control valve is used with the recirculating ball type steering system found in steering boxes, and is integral with the torsion bar.

The high pressure oil generated by the power steering pump is first directed through to the flapper control valves.

A series of flapper valves control the direction in which the fluid flows.

Fluid is allowed to flow from the pump to one side of the power steering piston and back to the reservoir.
Power Assisted Steering - Control Valves

**Flapper Valve Type**

Depending on the direction the steering wheel is turned determines which flapper valves open to allow fluid to flow and which other flapper valves stay closed.

The closed flapper valves act as pressure control valves, controlling the pressure at the power steering piston.

This is also dependent on the amount of force generated by the driver turning the steering wheel.
Power assisted hoses are constructed and designed to fit within the confinements of the engine bay/sub-frame area.

Made from layers of high spec synthetic rubber, and cord to provide additional strength and durability.

The coupled joints and pre-bent pipes are commonly made from zinc-dichromate and plated to resist corrosion.

Design to operate under extreme temperatures (+/-) and pressures depending on driving demands.

Combination of metal pipe and rubber, also minimises operating vibrations.
Power Assisted Steering - Oil Cooler

The power steering oil cooler is normally located within the radiator stack.

Positioned at the front of the vehicle to obtain and maximise the benefits of the forced air flow when the vehicle is in motion.

The power steering oil flows through the radiator matrix whilst the air circulates through the outer core fins.
Benefit of having a oil cooler is if the vehicle does a lot of towing or is driven in extreme hot climates.

Also, due to the coolers location, heat created by the other radiators can assist in maintaining a good operating temperature during extreme cold conditions.

Power Assisted Steering - Oil Cooler

Having a oil cooler assists in maintaining a good operating temperature.
Power Assisted Steering - Fluid

The power steering fluid transfers energy from the pump to the actuator.

It also lubricates and cools the moving parts.

The system typically holds up to 1 litre of fluid.

Many manufacturers recommend a service interval where the power steering fluid should be replaced.

It should not be confused with automatic transmission fluid (ATF), which is not compatible with power steering system components.
Power Assisted Steering - Fluid

Check & Top Up

Some vehicles have a clear reservoir where the power steering fluid can be seen.

The fluid level is checked against the markings on the side of the reservoir.

Alternatively, some reservoirs use a dipstick to indicate the fluid level.

The level should be between the minimum and maximum indicated levels.
Power Assisted Steering - Fluid

Check & Top Up

The colour of the power steering fluid can indicate if there is a problem.

The fluid should be either clear, pink, or red showing good condition.

It is common for power steering fluid to turn orange.

If it is very dark or has a burned smell then it will need replacing.
Power Assisted Steering - Inspection

Inspection and maintenance of the steering system is just as important as any other vehicle system.

The steering system has to meet manufacturing and governing standards.

Whether the steering is non-assisted or assisted power steering there are many mechanical or hydraulic components that need to be inspected for their serviceability.

Items to be inspected for serviceability:

- Fluid Level
- Drive Belt
- Hydraulic Pipes and Gear Housing
- Steering Wheel Free Play
- Steering Linkages
- Steering Joints and Bushes
- Idler Gears
- Steering Column
- Replacement of Power Steering Fluid (as per manufacturers guidance)
Close the valve on the pressure gauge and check the reading displayed.

Compare the reading obtained against the manufacturer’s specifications.

If the pressure is low, then replace the power-steering pump.
Power Assisted Steering - Pressure Testing

Re-open the valve on the pressure gauge and take a reading at 1000 rpm and at 3000 rpm.

Check the manufacturer’s specification and if the difference between the two readings is too great, then replace the flow control valve within the power steering pump.
Power Assisted Steering - Pressure Testing

Check that the valve on the pressure gauge is still fully open.

Then turn the steering wheel to full lock and take a reading.

If the pressure is lower than the manufacturer’s specification, then there is an internal leak in the gear housing.

The gear housing must be repaired or replaced.
Electro-hydraulic Steering - Introduction

As manufacturers looked to improve the overall performance of their vehicles steering and stability systems.

The first electronically controlled systems monitored and adapted the fluid pressure and engine speed depending on the driving demands.

With pressure switches or solenoids either located within the pump, high pressure pipe or in the control valve housing.

Enable the steering control module to adapt its pressure instantly and provide the driver with a better feel for the steering.
The hydraulic pump draws little power from the engine when the steering is not operating. During low speed manoeuvring, it can draw enough power to make the engine idle speed drop significantly.

The hydraulic system has a pressure switch that detects high load conditions and tells the engine control module to increase power to compensate.
Electro-hydraulic Steering - System Control

Power Steering Pump & Reservoir

Solenoid

Control Valve

Reservoir

Vane Pump

Solenoid
Electro-hydraulic Steering - System Control

Again, utilising the benefits of sensor/solenoid control via the electronic control module.

The systems could vary the amount of power assistance, depending on vehicle speed.

This is called ‘servotronic’.

At low speeds and when parking, a large force is provided by the power assistance.

For high speed manoeuvres such as changing lanes, less power assistance is provided.
With the introduction of electronics into automotive steering systems enables much more sophisticated control to be achieved.

Electric steering is more economical to run, and easier to package and install than the conventional hydraulic power steering systems.

Typically, electric and electro hydraulic power steering systems are also lighter and more compact than conventional hydraulic systems.

Both the electric power steering system and the hydraulic power steering system with a motor driven pump are now considered as viable alternatives to conventional hydraulic power steering systems because of their energy efficiency and size.
Electro-hydraulic Steering - Overview

Electrically Powered Hydraulic Steering (EPHS), replaces the customary drive belts and pulleys with a brushless motor that drives a high efficiency hydraulic power steering pump in a conventional rack and pinion steering system.

Pump speed is regulated by an electric controller to vary pump pressure and flow. This provides steering efforts tailored for different driving situations.

The pump can be run at low speed or shut off to provide energy savings during straight ahead driving.

An EPHS system is able to deliver an 80 percent improvement in fuel economy when compared to standard hydraulic steering systems.
Electrically assisted steering or EAS, is a power assist system that eliminates the connection between the engine and steering system.

EAS or direct electric power steering takes the technology a step further by completely eliminating hydraulic fluid and the accompanying hardware from the system, becoming a full “electronic power steering system” or EPS.

An EPS Direct electric steering system uses an electric motor attached to the steering rack via a gear mechanism and torque sensor.

A electronic control module and diagnostic software controls steering dynamics and driver effort.

Inputs include vehicle speed and steering, wheel torque, angular position and turning rate.
There are four primary types of electric power assist steering systems:

- Column Assist Type
- Pinion Assist Type
- Rack Assist Type
- Direct Drive Type
Electro-hydraulic Steering - Overview

Column Assist Type

In this system the power assist unit, controller and torque sensor are attached to the steering column.
Pinion Assist Type

In this system the power assist unit is attached to the steering gear pinion shaft.

The unit sits outside the vehicle passenger compartment, allowing assist torque to be increased greatly without raising interior compartment noise.
Electro-hydraulic Steering - Overview

Rack Assist Type

In this system the power assist unit is attached to the steering gear rack.

It is located on the rack to allow for greater flexibility in the layout design.
Electro-hydraulic Steering - Overview

Direct Drive Type

In this system the steering gear rack and power assist unit form a single unit.

The steering system is compact and fits easily into the engine compartment layout.

The direct assistance to the rack enables low friction and inertia, which in turn gives an ideal steering feel.
In all of these systems “Active control” as it is known provides constant feedback from sensors in the vehicle to the control module, which calculates sophisticated computer algorithms.

Sensors such as:

• Fluid Pressure (if electro/hydraulic)
• Fluid Temperature (if electro/hydraulic)
• Steering Angle
• Steering Torque
• Steering Speed
• Engine Speed
• Vehicle Speed
Electro-hydraulic Steering - Overview

This allows the steering system to react to the road, the weather and even the type of driver, and provide assistance to the front or rear road wheels independent of direct driver input.

Active steering produces enhanced steering response, stability and handing improvements to the vehicle without impacting the base steering feel.
Steer By Wire

In recent years vehicle manufacturers have developed systems such as throttle by wire and brake by wire. These systems are electronically controlled and the mechanical elements of these systems have been removed.

Latest engineering development shows the possibilities of steer by wire system.

This again will be a massive step forward in vehicle technology.

With a electronically controlled steering column and power rack, controlled by a module and a series of sensors to monitor other systems inputs and driver activities is something that must not be ignored.
4 Wheel Steering Systems - Introduction

During the late 1980’s a number of manufacturers introduced four-wheel steering in some of their vehicle range.

Why steer all four wheels?

• At lower speeds, turning the rear wheels in the opposite direction to the front wheels results in a smaller turning radius and faster cornering responses

• At high speeds, turning all four wheels in concert improves high speed stability

Not all were successful and due to manufacturing costs, complex designs, many were moth balled.
In later years, vehicle manufacturers have utilised the benefits of modern designed systems which are controlled by the latest technologies.

A number of different systems are now in production and all have their own functional design.

They fall into two categories:

• Active four wheel steering
• Passive rear wheel steering

Whether the manufacturers design uses twin steering racks, electronic actuators or specially designed suspension bushings, both categories can and do improve the vehicles steering and stability at high and low speed.
4 Wheel Steering Systems - Active

Active 4 Wheel Steering

In an active four-wheel steering system, all four wheels turn at the same time when the driver steers.

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.
4 Wheel Steering Systems - Active

Active 4 Wheel Steering

There can be controls to switch off the rear steer and options to steer only the rear wheel independent of the front wheels.

At low speed (parking) the rear wheels turn opposite of the front wheels, reducing the turning radius.

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.
Passive Rear Wheel Steering

Many modern vehicles have passive rear steering.

On many vehicles, when cornering, the rear wheels tend to steer slightly to the outside of a turn, which can reduce stability.

The passive steering system uses the lateral forces generated in a turn (through suspension geometry) and the specially designed bushings to correct this tendency and steer the wheels slightly to the inside of the corner.
4 Wheel Steering Systems - Passive

**Passive Rear Wheel Steering**

This improves the stability of the car, through the turn.

This effect is called compliance under-steer and it, or its opposite, is present on all suspensions.

On an independent rear suspension system it is normally achieved by changing the rates of the rubber bushings in the suspension.

Some rear suspensions typically have compliance over-steer due to the geometry set up.