MODULE 3

VARIOUS SUSPENSION AND STEERING SYSTEM

SUSPENSION SYSTEM PURPUSE AND FUNCTIONS

Street-driven cars and trucks use
a suspension system to keep the tires on the road and to provide acceptable riding comfort. A vehicle with a solid suspension, or no suspension, would bounce off the ground when the tires hit a bump. If the tires are off the ground, even for a fraction of a second, loss of control is possible. The purpose of the suspension is to provide the vehicle with the following:

1. A smooth ride
2. Accurate steering
3. Responsive handling
4. Support for the weight of the vehicle
5. Maintenance of acceptable tire wear

SUSPENSION PRINCIPLE

Suspensions use various links, arms, and joints to allow the wheels to move freely up and down; front suspensions also have to allow the front wheels to turn. All suspensions must provide for the following Supports.

Transverse (or side-to-side) wheel support:

The wheels of the vehicle move up and down, the suspension must accommodate this movement and still keep the wheel from moving away from the vehicle or inward toward the center of the vehicle

Longitudinal (front-to-back) wheel support:
As the wheels of the vehicle move up and down, the suspension must allow for this movement and still keep the wheels from moving backward whenever a bump is hit.
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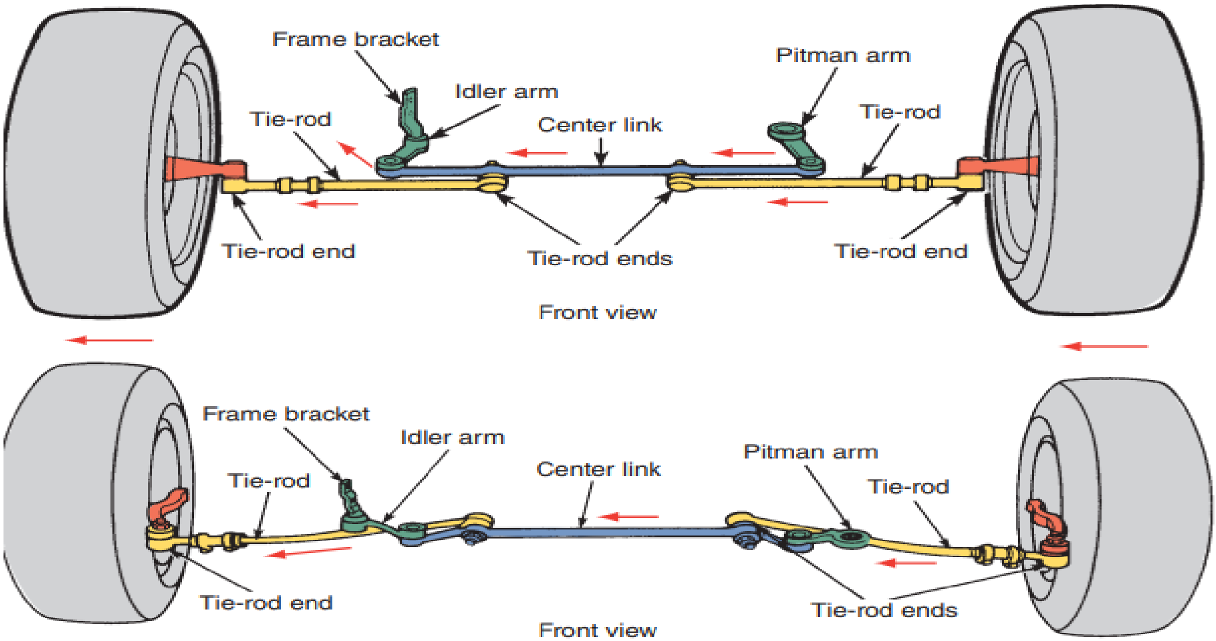
SUSPENSION PARTS

1) STEERING KNUCKLE

steering knuckle is hard to classify either as part of the suspension or as part of the wheel. A knuckle serves two purposes:

- To join the suspension to the wheel
- Usually includes the spindle where the front wheel bearings are attached
- To provide pivot points between the suspension and wheel.

Knuckles are used with independent suspensions and at the wheels that steer the vehicle. The only knuckle that uses a **kingpin** is a steering knuckle on an I-beam or twin I-beam front suspension



2) CONTROL ARMS

A **control arm** is a suspension link that connects a knuckle or wheel flange to the frame. One end of a control arm attaches to the knuckle or wheel flange, generally with either a ball joint or bushing. The opposite end of the arm, which attaches to a frame member, usually pivots on a bushing The end attached to the frame must pivot to allow the axle or knuckle to travel vertically.

3) BALL JOINTS

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Ball joints are actually ball-andsocket joints, similar to the joints in a person's shoulder. Ball joints allow the front wheels to move up and down, as well as side to side A vehicle can be equipped with coil springs, mounted either above the upper control arm *or* on the lower control arm If the coil spring is attached to the top of the upper control arm, then the upper ball joint is carrying the weight of the vehicle and is called the **load-carrying ball joint.** The lower ball joint is called the **non-load-carrying,** or *follower*, **ball joint**.

4) STRUT RODS

Some vehicles are equipped with round steel rods that are attached between the lower control arm at one end and the frame of the vehicle with rubber bushings, called strut rod bushings, at the other end. The purpose of these **strut rods** is to provide forward/backward support to the control arms. Strut rods are used on vehicles equipped with MacPherson struts and many short/long-arm-type suspensions. The bushings are very important in maintaining proper wheel alignment while providing the necessary up-and-down movement of the control arms during suspension travel. Strut rods prevent lower control arm movement back and forth during braking.

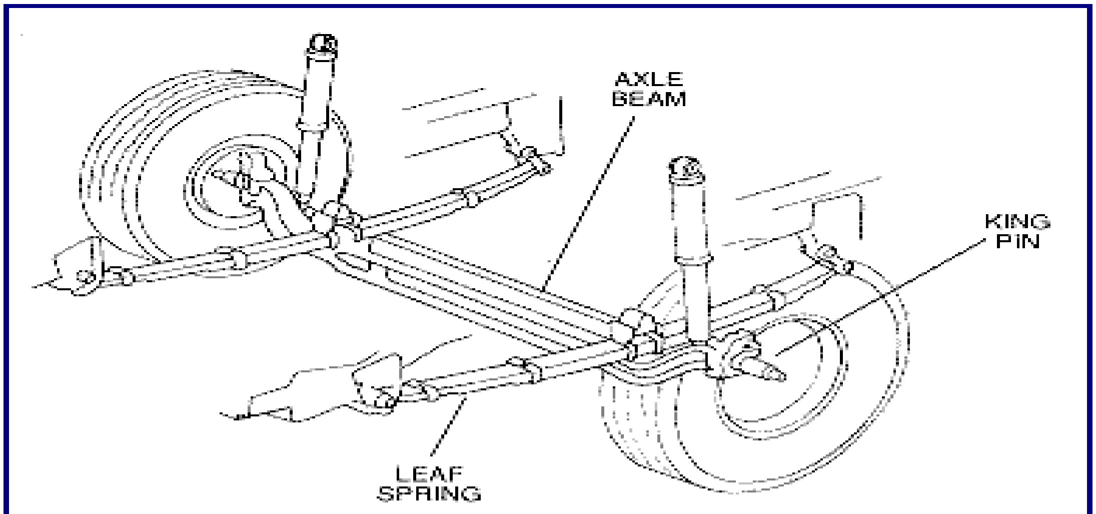
5) STABILIZER BAR

Most cars and trucks are equipped with a **stabilizer bar** on the front suspension, which is a round, hardened steel bar (usually SAE 4560 or 4340 steel) attached to both lower control arms with bolts and rubber bushing washers called stabilizer bar bushings. A stabilizer bar is also called an anti-sway bar (sway bar) or anti-roll bar (roll bar). A stabilizer bar operates by *twisting* the bar if one side of the vehicle moves up or down in relation to the other side, such as during cornering, hitting bumps, or driving over uneven road surfaces.

FRONT SUSPENSION TYPES

1) SOLID AXLE SUSPENSION

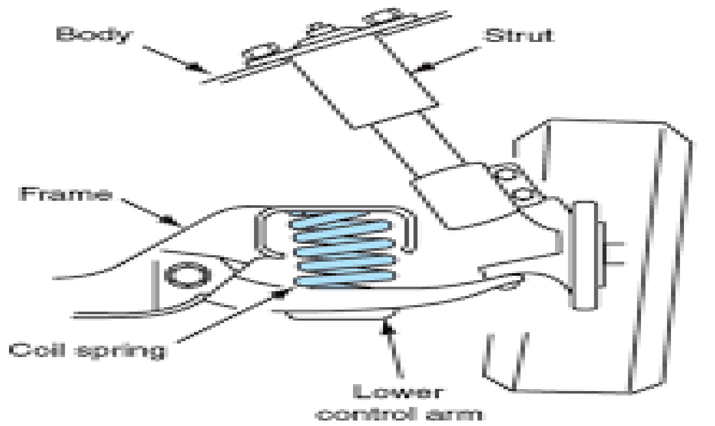
Early cars and trucks used a solid (or straight) front axle to support the front wheels. A solid-axle front suspension is very strong and is still being used in the manufacture of medium and heavy trucks. The main disadvantage of solid-axle design is its lack of ride quality. When one wheel hits a bump or dip in the road, the forces are transferred through the axle to the opposite wheel. Solid axles are currently used in the rear of most vehicles.



Solid Axle

2) MacPherson strut

Strut suspension can be of several types. A MacPherson strut includes the suspension spring that transfers the weight of the body to the wheel. A MacPherson strut is the main, load-carrying suspension spring. A MacPherson strut typically incorporates an upper and a lower spring seat, a shock absorber mount and dust cap, a dust cover for the piston rod, and a bump stop. The upper mount secures the upper spring seat to the strut tower. A rubber bushing at the top of the strut absorbs vibrations. In most applications, a bearing on the top of a front-wheel strut allows it to rotate on the vertical steering axis without rubbing against the strut tower when the steering knuckle turns. The lower spring seat is attached to the strut casing. The piston rod dust cover is similar to the dust cover on a conventional shock absorber, and a bump stop at the top of the piston rod keeps the strut from bottoming out during suspension jounce.



Modified MacPherson strut front suspension system.

REAR SUPENSION SYSTEM

1) **SOLID AXLE**

A solid axle can be used at the rear of either a rear-wheel-drive or front-wheel-drive vehicle. On a rear-wheeldrive vehicle, a solid rear axle consists of the differential gears and axle shafts inside a solid housing. On a front-wheel-drive vehicle, a solid axle is usually a simple U-shaped or tubular beam that may contain a torsion bar, rod, or tube to allow some twisting action. Certain characteristics apply to any solid rear axle, while other characteristics vary by the type of suspension used to attach the axle to the frame. Solid axles have some handling characteristics that are inferior to those of an independent suspension. Disadvantages of a solid axle include the following:

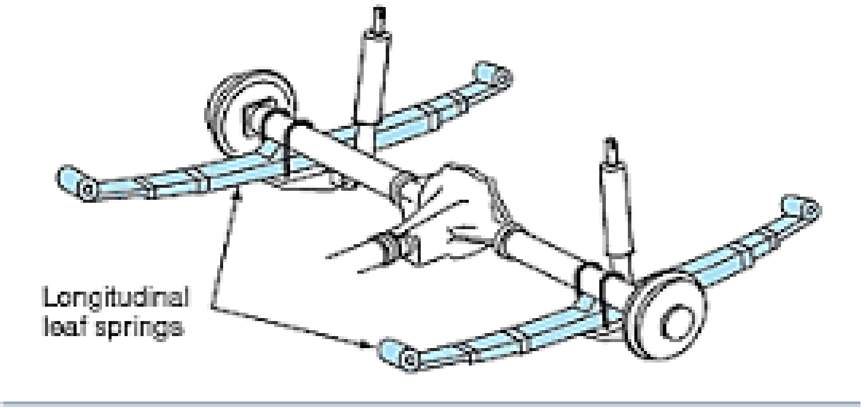
- Increased proportion of unsprung weight
- Side-to-side road shock transference
- Poorer tire adhesion

2) LEAF SPRING REAR SUSPENSIONS

A leaf spring suspension is a simple system because it does not require control arms to brace and position the axle. The leaf springs link the axle to the frame and effectively serve two purposes:

- Absorbing road shock
- Locating the axle under the vehicle
- Most rear-wheel-drive trucks use a solid rear axle with leaf springs in an arrangement called a Hotchkiss drive

  Leaf springs on a driven axle control axle windupby transferring force from the axle housing to the frame. The front portion of the leaf spring, from the axle housing to the frame mount, acts like a trailing control arm. However, if the front section of the leaf spring is too flexible, it may not control axle windup as well. To compensate, some manufacturers make the front section of the spring shorter, and therefore less flexible, than the rear section.



Leaf-spring rear suspension system.

3) **TRAILING ARM REAR SUSPENSIONS**

A trailing arm extends from a frame crossmember located ahead of the rear axle back to the axle housing or a wheel knuckle. Trailing arms run parallel to the centerline of the chassis A trailing arm mounts to the frame with bushings, which allows the arm to pivot as the wheel rides over bumps. Some rear suspensions use two sets of trailing arms, one set positioned higher in the chassis than the other. Although the arms in this type of arrangement are commonly referred to as the upper control arms and lower control arms, they are usually called trailing arms. The word trailing applies to any link where the supported member trails the arm. Trailing arms may be used to brace either a driven or nondriven solid rear axle against front-to-rear forces, but they do not provide much resistance to side-to-side, or lateral, forces. The axle itself is one means of locating the wheels side-to-side, and solid rear suspensions frequently use another rod to provide additional support. Trailing arms transfer axle windup force to the frame and control front-to-rear axle movement. On a few models, especially those with a high-performance suspension, a torque arm provides additional resistance to axle windup. A trailing arm rear suspension on a nondriven solid axle virtually always includes a track rod, also called a Panhard rod. A track rod is a rod attached to the body or frame on one end and the rear axle on the other.

INDEPENDENT REAR SUSPENSION

The use of independent rear suspension, called IRS, has grown dramatically over the past several decades to the point where such systems are now fairly common, especially on front-wheel-drive vehicles and some rear-wheel-drive vehicles. Although rarely used on trucks, a number of rear-wheel-drive vehicles do feature an independent rear suspension. The reduction in unsprung weight is particularly noticeable for driven axles, which are constructed to transfer the weight of the differential and axles to the frame.A vehicle with an independent rear suspension rides and handles better than a similar vehicle equipped with a solid rear axle. An SLA-type of independent suspension may be used at the rear of a rear-wheel-drive vehicle.

ELECTRONIC SUSPENSION SYSTEM

PURPOSE AND FUNCTION : Sensors and switches provide input to the electronic control module (ECM), or system computer. The ECM, which may also be referred to as the electronic control unit (ECU), is a small computer that receives input in the form of electrical signals from the sensors and switches and provides output electrical signals to the system actuators. The electrical signal causes an actuator to perform some type of mechanical action.

TYPES OF ELECTRONIC SUSPENSION

1. Selectable Ride
2. Automatic Level Control
3. Air Suspension
4. Computer Command Ride
5. Real-Time Dampening/Road-Sensing Suspension
6. Vehicle Stability Enhancement System
7. Magneto-Rheological Suspension

AIR SUSPENSION SYSTEM

Air Suspension (AS) is a system very similar to the ALC system. The purpose of the AS system includes: 1. Keep the vehicle visually level

2. Provide optimal headlight aiming

3. Maintain optimal ride height

The AS system includes the following components:

An air suspension compressor assembly Rear air springs Air suspension sensors The AS system is designed to maintain rear trim height within 3/16 inch (4 mm) in all loading conditions, and the leveling function will deactivate if the vehicle is overloaded. Air Suspension (AS) is a system very similar to the ALC system. The purpose of the AS system includes: 1. Keep the vehicle visually level 2. Provide optimal headlight aiming 3. Maintain optimal ride height The AS system includes the following components: An air suspension compressor assembly Rear air springs Air suspension sensors The AS system is designed to maintain rear trim height within 3/16 inch (4 mm) in all loading conditions, and the leveling function will deactivate if the vehicle is overloaded. The ignition and brake light switches tell the ECM whether the ignition switch is on or off, and if the brake pedal is depressed. The dome light switch indicates whether any doors are open. The on/off switch disables the air spring system to avoid unexpected movement while towing or servicing the vehicle.

WORKING

The ECM receives information from the height sensors indicating that the trim height is too high or too low, and it energizes the actuators to add or bleed air from the air springs. The system actuators can still operate for up to an hour after the ignition is switched off. Any time the ignition is switched to the “run” position, the ECM raises the vehicle, if necessary, within the first 45 seconds. If trim height is too high and the vehicle must be lowered, the ECM delays doing so for 45 seconds after the ignition is switched on. An air compressor with a regenerative dryer provides the air change required to inflate the air springs on the air suspension system, and a vent solenoid is used to relieve air pressure and deflate the springs.

STEERING LINKAGES

The term steering linkage is applied to the system of pivots and connecting parts placed between the steering gear and the steering arms that are attached to the front or rear wheels that control the direction of vehicle travel. The steering linkage transfers the motion of the steering gear output shaft to the steering arms, turning the wheels to maneuver the vehicle. The steering arms are the part of the steering knuckle that curve in toward the center of the vehicle and connect to the steering linkage.

1) Parallelogram Steering Linkage.

A parallelogram type of steering linkage arrangement was at one time the most common type used on passenger cars. It is used with the short-long arm suspension and a recirculating ball steering gearbox. Parallelogram steering linkage can be placed behind the front-wheel suspension of the front-wheel suspension . The components in a parallelogram steering linkage arrangement are the Pitman arm, idler arm, links, and tie-rods.

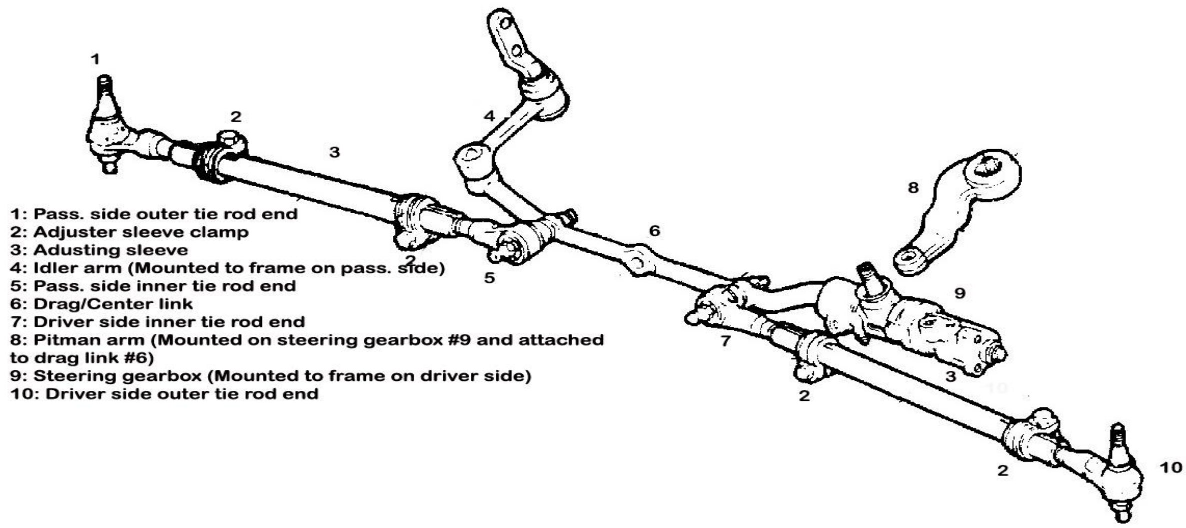
Pitman Arm : The Pitman arm) connects the linkage to the steering gear located at the base of the column. It transmits motion from the gear to the linkage, causing the linkage to move left or right to turn the wheels in the appropriate direction.

Idler Arm : The idler arm or idler arm assembly s normally attached, on the opposite side of the center link, from the Pitman arm and to the car frame, supporting the center link at the correct height.

Links: Links, depending on the design application, can be be referred to as center links, drag or steering links Their purpose is to control sideways linkage movement, which changes the wheel's direction. Because they usually are also mounting locations for tie-rods, they are very important for maintaining correct toe settings.

Tie-Rods : Tie-rods and tie-rod assemblies make the final connections between the steering linkage and steering knuckles. In a parallelogram steering linkage, the tie-rods have ball socket assemblies at each end. One end is attached to the steering arm and the other end to the center link.

Parts of a Parallelogram/Steering Gearbox Steering System



2) <u>Rack and Pinion Steering Linkage</u>

A rack and pinion is lighter in weight and has fewer components than parallelogram steering . Tie rods are used in the same fashion on both systems, but the resemblance stops there. Steering input is received from a pinion gear attached to the steering column. This gear moves a toothed rack that is attached to the tie-rods In the rack and pinion steering arrangement, there is no Pitman arm, idler arm assembly, or center link. The rack performs the task of the center link. Its movement pushes and pulls the tie-rods to change the wheel’s direction. The tie-rods are the only steering linkage parts used in a rack and pinion system

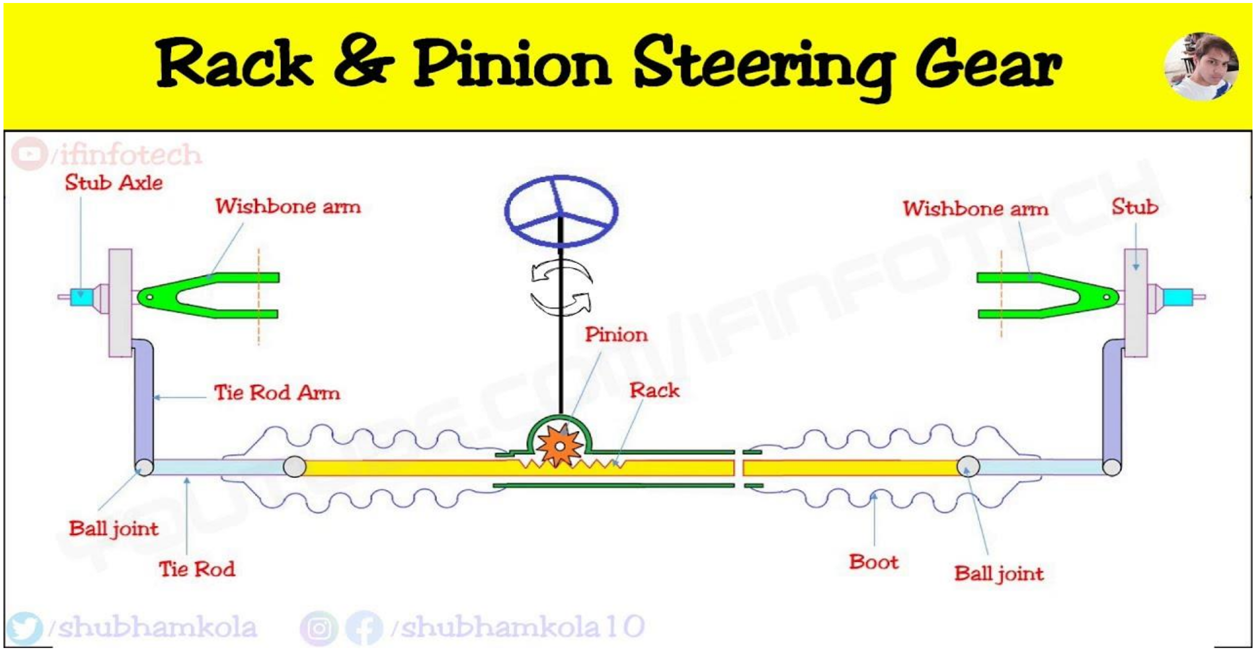
<u>COMPONENTS</u>

Rack : The rack is a toothed bar contained in a metal housing. The rack maintains the correct height of the steering components so that the tie-rod movement is able to parallel control arm movement.

Pinion :The pinion is a toothed or worm gear moved by the steering wheel. The pinion gear meshes with the teeth in the rack so that the rack is propelled sideways in response to the turning of the pinion.

Yoke Adjustment : The rack-to-pinion lash, or preload, affects steering harshness, feedback, and noise.

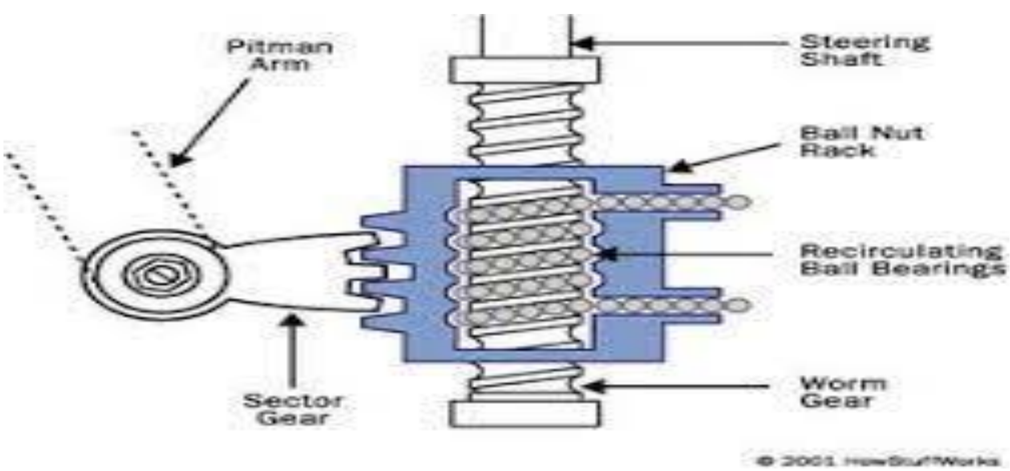
Tie-Rods : Tie-rods in rack and pinion systems are very similar to those used on parallelogram systems. They consist of inner and outer ends. Typically, the rod of the inner tie-rod threads into the outer tie-rod.



TYPES OF STEERING GEAR

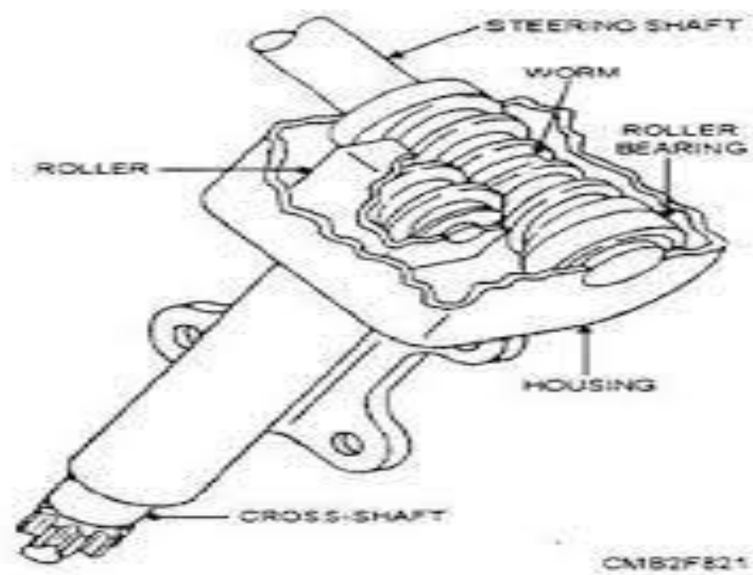
1) RECIRCULATING BALL STEERING

A recirculating ball steering gear is the most commonly used conventional steering gear. The end of the steering gear input shaft, or worm shaft, splines to the steering shaft U-joint and provides rotary input to the steering gear. An oil seal prevents fluid leakage where the input shaft enters the steering gear housing. At the top and the bottom of the worm gear are the upper and lower thrust bearings. The upper bearing cup seats in the housing, and the lower bearing cup seats in the adjuster plug. The thrust bearings reduce friction between the worm gear and the steering gear housing and control worm endplay. The adjuster plug at the lower end of the worm gear holds the worm gear, shaft, and bearings inside the steering gear housing.



2) WORM AND ROLLER STEERING GEAR BOX

The worm and rotter steering gear is quite similar to the worm and sector, except a roller is supported by ball or rotter bearings within the sector mounted on the pitman arm shaft. These bearings vassist in reducing sliding friction between the worm and sector. As the steering wheel turns the worm, the roller turns with it, forcing the sector and pitman arm shaft to rotate. he hourglass shape of the worm, which tapers from both ends to the center, affords better contact between the worm and roller in all positions. This design provides a variable steering ratio to permit faster and more efficient steering. variable steering ratio" means that the ratio is larger at one position than another. Therefore the wheels are turned faster at certain positions than at others. At the center or straight-ahead position, the steering gear ratio is high, giving more steering control. However, as the wheels are turned, the ratio decreases so that the steering action is much more rapid. This design is very helpful for parking and maneuvering the vehicle.



Differences in steering wheel and column designs include fixed column, telescoping column, tilt column, manual transmission, floor shift, and automatic transmission column shift. The tilt columns may feature preset detents that have at least five driving positions (two up, two down, and a center position). Many tilt systems allow for setting the position of the column anywhere between a fixed upper and lower limit. A feature on newer cars and trucks is power tilt and telescoping steering columns. Two small electric motors are used to move the column and wheel into the driver’s desired position. One motor is used for tilt while the other motor is for the telescoping function. Powered columns are common on vehicles with programmable memory or personality presets for different drivers.

Collapsible steering column

The steering wheel is used to produce the turning effort. The lower and upper covers conceal parts. The universal joints rotate at angles to connect the steering shaft to the steering gear. Support brackets are used to hold the steering column in place. Assorted screws, nuts, bolt pins, and seals are used to make the steering wheel and column perform correctly. Since 1968, all steering columns have a collapsible feature that allows the column to fold into itself on impact. This feature prevents injury to the driver.

Power steering system

The power-steering unit is designed to reduce the amount of effort required to turn the steering wheel. It also reduces driver fatigue on long drives and makes it easier to steer the vehicle at slow road speeds, particularly during parking. Power steering can be broken down into two design arrangements: conventional and nonconventional or electronically controlled. In the conventional arrangement, hydraulic power is used to assist the driver. In the nonconventional arrangement, an electric motor and electronic controls provide power assistance in steering.

Integral Piston System

The integral piston system is used in conventional recirculating ball power-steering systems. It consists of a power-steering pump and reservoir, powersteering pressure and return hoses, and steering gear. The power cylinder and the control valve are in the same housing as the steering gear

Power-Assisted Rack and Pinion System

Power-assisted rack and pinion components are basically the same as for manual rack and pinion steering except for the hydraulic control housing. The power-assisted rack and pinion system are also similar to the integral system because the power cylinder and the control valve are in the same housing. The rack housing acts as the cylinder and the power piston is part of the rack. Control valve location is in the pinion housing . Turning the steering wheel moves the valve, directing pressure to either end of the back piston. The system utilizes a pressure hose from the pump to the control valve housing and a return line to the pump reservoir. This type of steering system is common in modern vehicles.

Electronically Controlled Power Steering Systems

The object of power steering is to make steering easier at low speeds, especially while parking. However, higher steering efforts are desirable at higher speeds in order to provide improved down-the-road feel. The electronically controlled power-steering (EPS) systems provide both of these benefits. The hydraulic boost of these systems is tapered off by electronic control as road speed increases. Thus, these systems require well under 1 pound (4.4 N) of steering effort at low road speeds and 3 pounds plus (13.2 N) of steering effort at higher road speeds to enable the driver to maintain control of the steering wheel for improved high-speed handling. A rotary valve electronic power-steering system consists of the power-steering gearbox, powersteering oil pump, pressure hose, and the return hose. The amount of hydraulic fluid flow (pressure) used to boost steering is controlled by a solenoid valve that is identified as its PCV (pressure control valve).