Two and Three Wheeler Technology

MODULE : 1

Contents:

- Classification & layouts of two wheelers (motorcycles, scooters, mopeds). Layout of mopeds, scooter and motor cycle. Load on the frame, Components of frame, Mounting provisions of frame, Tubular frame. Engine based frame, Twin spar frame, Monocoque, frame, Frame material, Body work, Ergonomic considerations.

- Spoked wheel, Pressed steel wheels, Alloy wheels. Requirements of tyres, Designation of tyres. Cross ply and radial ply tyres, Tyre with tube and tubeless tyres. Inflation pressure. Working principle, construction, charging and discharging, capacity rating of lithium-iron battery, Battery management system of lead acid battery and lithium iron battery

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Two-wheeler is a term used to refer to any vehicle that has two wheels. Two-wheelers are powered by internal combustion engines or electric motors and are commonly used for personal transportation, commuting, and recreational purposes

Classification of two-wheelers

- Mopeds
- Scooters
- Motorcycles

Mopeds

Mopeds are also known as Auto cycles or Moppets. Mopeds are used for short distance travel with just the driver or with a pillion passenger like daily travel to and from nearby place. Mopeds are equipped with pedals which can be used for starting. Its construction is very simple and operating cost is also low. The capacity of fuel storage is very less. Mopeds should not be used frequently for long distance travel with heavy weights.

Scooters

Scooters are fast in speed than mopeds. Scooters are equipped with one single unit consisting the engine and transmission. Foot board is an integrated part used to support extra luggage. Engine is located at rear under because of which handling and controlling of scooter at high speed is difficult. Scooters can be used for comparatively longer distance travel with baggage and a pillion passenger. The main attraction of a scooter is low fuel consumption. Operating cost for scooters is also very less.

Motorcycles

A motorcycle is also called a motorbike, or simply bike. Motorcycles are designed for travling through congested urban traffic, sport and racing, or cross-country conditions. Motorcycles are fitted out with the medium to high powered engines and mainly using for long journeys on any kind of roads with luggage and a pillion passenger. As engine is located in middle of vehicle, controlling and handling the motorcycle is easy.

Motorcycles can be classified into

Street Commuter Bike, Endure Bike, Cruise Bike, Sport Bike

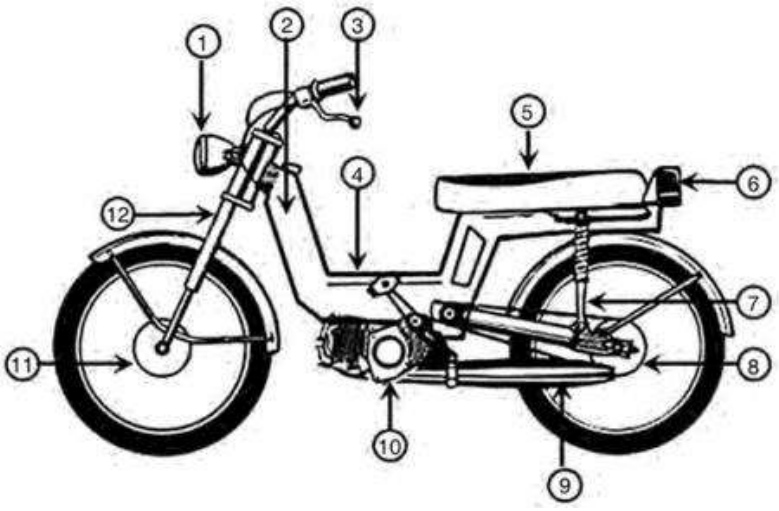
TWO-WHEELER LAYOUTS

1) Layout of Moped

Mopeds are tiny and elegant vehicle with a tough frame and a small capacity engine. The frame itself works as a vehicle body and fuel tank is an integral part of this frame in the front side of vehicle. All components are mounted on the same body.

Generally, moped uses two-stroke, single cylinder air cooled engine. Capacity of engine falls between 50 cc to 80 cc. Engine is located in middle, under the fuel tank. From engine to rear wheel, the power transmission takes place by means of centrifugal automatic clutch and belt, belt pulley and reduction gear unit. It is also provided with auxiliary transmission consists of pedals, sprockets with crank, roller chain.

A unique characteristic of moped is its pedal starting. The engine is equipped with pedal for cranking purpose. A declutching lever is provided under the rear brake lever to engage and disengage the engine from transmission during pedal start. Generally moped uses a mixture of petrol and 2T motor oil at 2%, i.e. About 20 ml of oil for each litre of petrol. It comes with bench type seat for passenger as well as pillion. Suspensions are not too effective as compare with scooter or motorcycle. All mopeds use the mechanical type brake for both front and rear. Mopeds are equipped with necessary instrumentation like speedometer, odometer and fuel gauge.



1. Head Lamp
2. Fuel Tank
3. Brake Lever
4. Frame/Body
5. Seat
6. Tail Lamp
7. Rear Suspension
8. Rear Brake
9. Exhaust
10. Engine with Pedal
11. Front Brake
12. Front Suspension

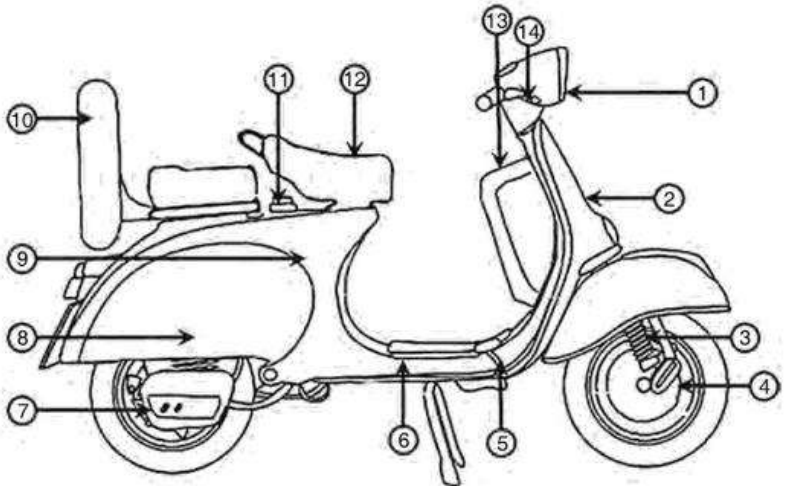
2) Layout of Scooter

Figure shows a basic layout of scooter. It consists of backbone type integrated chassis. Chassis is fabricated with steel tubes and pressed steel sections, which are welded together. A detachable pressed steel dome-shaped toolbox and engine bonnet are used as rear body panels. A FRP made front dome is used as leg shield and serves the purpose of storage compartment.

The four-stroke single cylinder engine is located at rear below the seat. In scooters with manual transmission, drive is provided to the rear wheel through clutch and four-speed gearbox. Modern scooters make use of CVT in which trapezoidal belt and pulley along with the centrifugal clutch is used for transmission. Generally, the engine is started by means of electric start but a kick-start is also provided on the right hand side of the scooter.

Earlier, scooters were equipped with split seat for driver and pillion passenger. Nowadays, all scooters come with bench type seat which makes ride comfortable for driver. Some modern scooters are fitted out with disc brake at front while drum brake is almost universal on all models. Leading link or trailing link type suspension system is used at front and a mono-shock suspension is used at rear. Comparatively, suspensions have less travel and are not so effective if compared with motorcycle.

1. Head Lamp
2. Front Dome
3. Front Suspension
4. Front Brake
5. Rear Brake Lever
6. Foot Board
7. Exhaust
8. Engine Compartment
9. Body
10. Spare Wheel
11. Fuel Tank (Below Seat)
12. Seat
13. Storage Space
14. Front Brake Lever



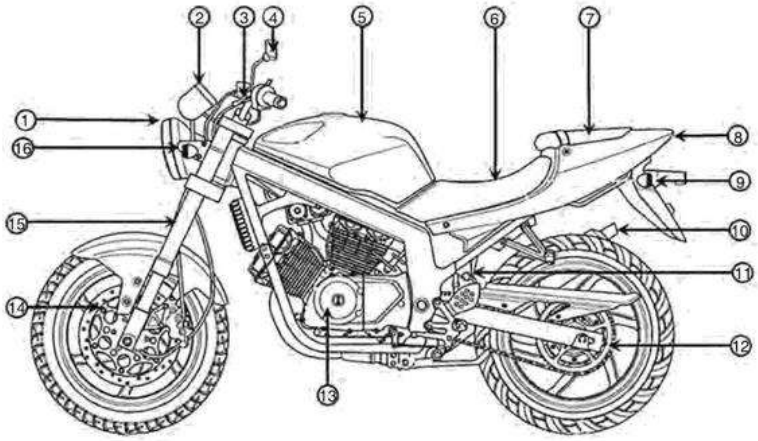
3) Layout of Motorcycle

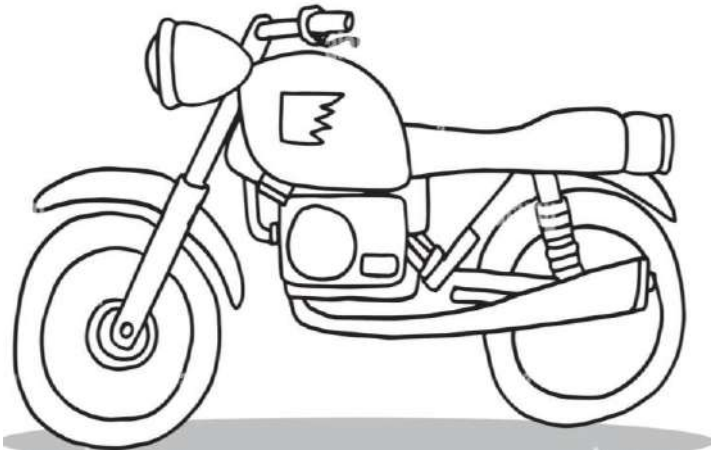
It consists of Tubular, Pressed steel or Engine-based chassis. The motorcycle frame provides a strong, rigid structure upon which attach the necessary components. The bike's characteristics are derived from frame geometry. The engine is located at middle of the bike. This engine working on petrol and is supported to the chassis through the crankcase mountings provided on the engine casing. This engine is more powerful with higher capacity than scooters and mopeds.

Transmission is provided by driving the rear wheel through clutch, and gear box, and chain drive. It uses four, five or six speed gear box with sequential gear box in oil baths. The engine is started by means of a kick start or electric start provided.

Generally the front suspensions are telescopic type. Rear suspension makes use of swing arm with twin shock or mono shock arrangement. Disc brakes at both the ends are now universal design adopted by all manufacturers though some small capacity motorcycle still use drum brake at rear. Fuel storage capacity is far higher than mopeds and scooters to compete long journeys.

1. Head Lamp
2. Instrument Panel
3. Clutch Lever
4. Rear view mirror
5. Fuel Tank
6. Seat
7. Pillion Seat
8. Tail Lamp
9. Rear Turn Indicator
10. Exhaust
11. Rear Suspension
12. Chain Drive
13. Engine
14. Front Brake
15. Front Suspension
16. Front Turn Indicator





FRAME AND BODY

The two-wheeler frame provides a strong, rigid structure on which all the systems and components are attached. A lightweight frame helps to achieve better overall balancing of the vehicle and improves the mileage. The frame rigidly holds the wheels in straight line and allows relative motion when required. Above all, the frame holds the power plant, which generated maximum vibration on the vehicle.

The shocks coming from the road surface is finally taken and damped by the frame. Failure of frame results from excessive loading, crash and fatigue.

Function of the frame

1. To support the chassis components and the body.

2. To withstand static and dynamic loads without deflection.

Load on the frame

The frame is the basic unit which withstands major loads acting on the vehicle during dynamic condition. Following are the various load which likely to produce deflection in the frame.

Vertical bending : Weight of the vehicle and the rider, which causes vertical bending of the frame. Pillion passenger or luggage also adds up in this force.

Longitudinal torsion: Vertical loads when the vehicle comes across a bump or hollow, which results in longitudinal torsion due to one wheel lifted with other wheel at the usual road level.

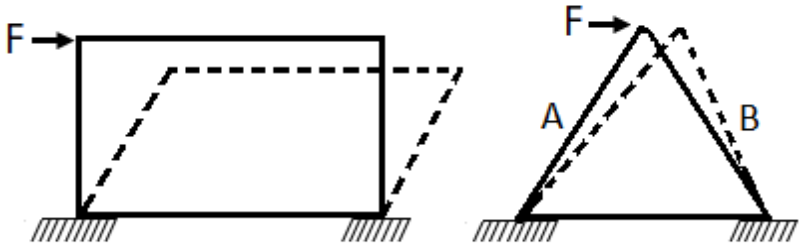
Lateral bending: Loads due to road camber, side wind, cornering force while taking turn, which result in lateral bending of the frame.

Frame distortion: Due to wheel impact with road obstacles may cause that particular wheel remain obstructed while other wheel tends to move forward, distorting the frame in longitudinal direction.

Bending of frame in vertical plane: Engine torque and braking torque cause to bend the frame in vertical plane.

Sudden impact loads during collision, which may result in a **general collapse.**

Law of triangulation



Consider the two simple structures illustrated in Figure. If their bases are fixed while a force (F) is applied as shown, then the four-sided frame may distort to a diamond shape, with complete collapse prevented only by the tubes' resistance to bending at the corners.

In the triangular frame, It can distort only by a change in length of any one or all three sides. A two-wheeler frame may comprise several such triangles.

The four-sided frame may be stiffened by adding one or two diagonals, so converting it to two or four triangles. If only one bracing strut is added, it must be of sufficient diameter to resist compression loads. But if two diagonals are added even with thin wall thickness, one or the other will be subject to tension under any type of loading, and this one will complete the structure.

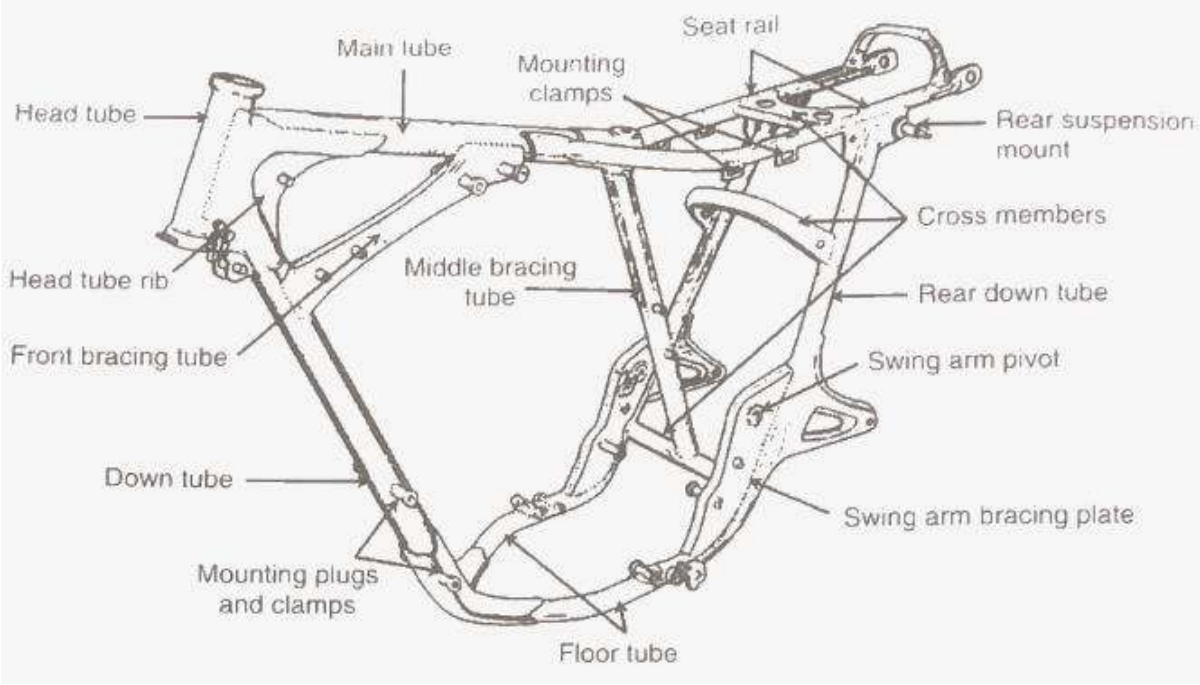
In designing a triangulated frame, simple considerations of space and shape may present difficulties, since some engines don't give room to accommodate in at type of construction. This problem can be resolved using either external triangulation or internal triangulation.

Components of frame

A conventional two-wheeler frame can be divided into two parts ***front frame*** and ***rear frame***.

- The front frame includes head tube, main tube, down tube and floor tube which are the major load bearing members of the frame.

- The rear frame includes seat rails, rear down tube, swing arm bracing plate, swing arm pivot and cross members.



HEAD TUBE: The head tube is the tube at the top of the frame where front fork assembly is attached. Inside the head tube two sets of ball bearings and adjusting nut re provided. The angle of head tube decides the steering geometry. The angle of head tube is important and it affects the high speed stability. The head tube angle is first set and fixed on the fixture during manufacturing and the rest part of the frame is fabricated accordingly.

MAIN TUBE: The main tube carries majority loads during dynamic condition, therefore it also known as backbone. It is fabricated with larger diameter tube to provide sufficient bending and torsional stiffness. Modern frame also includes pressed steel plates, which gives strength to the main tube.

HEAD TUBE RIB: The head tube rib is welded between the head tube and the main tube. It increases stiffness and keeps the head tube at decided angle. It also provides clamping point for the front wiring harness.

DOWN TUBE: Just like the main tube, the down tube also carries various forces. It goes down from the head tube to support further structure of the frame. The diameter of the down tube is almost same like the main tube. It also contains front mounting points for the engine. The tubular frames, actually, are classified with respect to the number of down tube.

FLOOR TUBE: The floor tubes are intended to support engine and transmission from the bottom and therefore the frame splits into two at the point where floor tube starts. The floor tubes also welds a bottom cross bracing plate on which front foot pegs and stands are mounted.

FRONT BRACING TUBE: The front bracing tube is welded between the main tube and the down tube to accomplish the law of triangulation. The frame is stiffened by adding this diagonal bracing. It may be fabricated with smaller diameter tube or with pressed steel bar.

SEAT RAILS: Seat rails fall under the rear frame and tolerates forces those generated because of weight. Therefore, the diameter of seat rail tubes is kept smaller. The seat rails mounts various components like seat, battery, seat latch, rear body panels and rear fender.

CROSS MEMBERS: Cross members at various locations are used to sustain lateral forces. These cross members avoids buckling and bending of frame in lateral direction. They are made with tubes or with steel bars.

REAR DOWN TUBE: The rear down tube connects the seat rails with the floor tubes by completing the triangular structure. It supports the cantilever seat rails welded from one end. They may have mounting points for the rear foot pegs, rear brake lever and gear shifting lever.

MIDDLE BRACING TUBE: The middle bracing tubes are used between the main tube and the floor tubes to complete the triangular structure. Modern frames use the middle bracing tubes or plates as a replacement of the rear down tube. This facilitates use of small rear down tube with reduced diameter which further helps to shift the COG nearer to the engine.

SWING ARM BRACING PLATE: The swing arm bracing plate is inserted on the rear down tube or on the middle bracing tube. It incorporates a pivot point for the swing arm. It also provides a rear mounting point for the engine and transmission. It is probably, second stiffest part on the frame.

MOUNTING PLUGS AND CLAMPS: Mounting plugs and mounting clamps are permanently welded at various locations to mount various systems and components. Necessary damping elements are inserted in these mountings plugs to damp the vibrations.

TYPES OF MOTORCYCLE FRAMES

1) Tubular frame
    - *Backbone type frame*
    - *Double beam type frame*
    - *Single cradle frame*
    - *Double cradle frame*
    - *Trellis frame*
    - *Step-through frame*
2) Engine-based frame
3) Twin-spar frame
4) Monocoque frame

TUBULAR FRAME

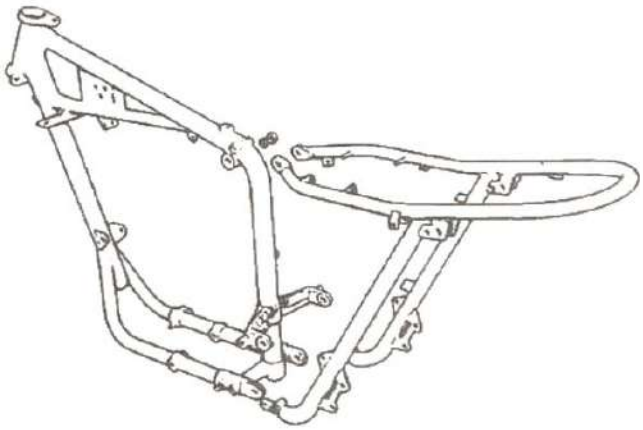
The tubular frames are conventionally used on smaller capacity two wheelers. These frames make use of metal tubes with different diameters to achieve sufficient structural efficiency. Their triangular layout is determined primarily by space availability. Many vehicles also use square or rectangular tubes instead of circular. With tubular frame, it is possible to attain better rigidity along with excellent handling characteristics. Small capacity vehicle uses single main tube configuration while high capacity vehicles with bigger engines demand for double main tubes configuration. Fundamentally, following types of tubular frames are generally used on various two wheelers.

Types of tubular frames

- *Backbone type frame*
- *Double beam type frame*
- *Single cradle frame*
- *Double cradle frame*
- *Trellis frame*
- *Step-through frame*

1) Backbone type frame:

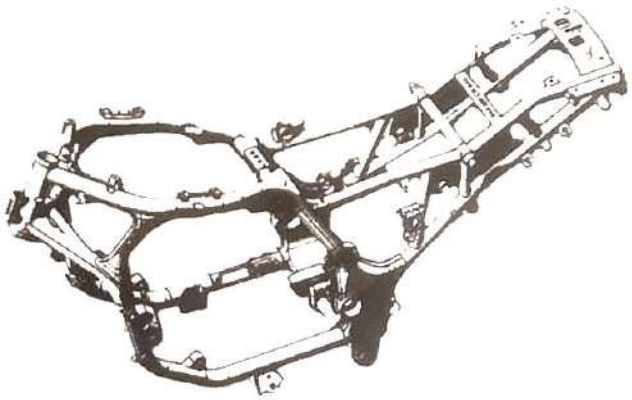
This frame uses a single large diameter tube which connects the steering head with the rear suspension pivot, serving the purpose of spine and therefore known as backbone frame. This type of construction allows freedom in the overall design of the vehicle and the production is more economical. The engine is supported between main tube, down tube and floor tubes. Fabrication of backbone type frame is very easy and required less skill. This frame is used on some early as well as current custom motorcycles. Moreover, this frame is best suitable for vertical and inclined single cylinder engines.



Backbone Frame.

2) Double beam type frame:

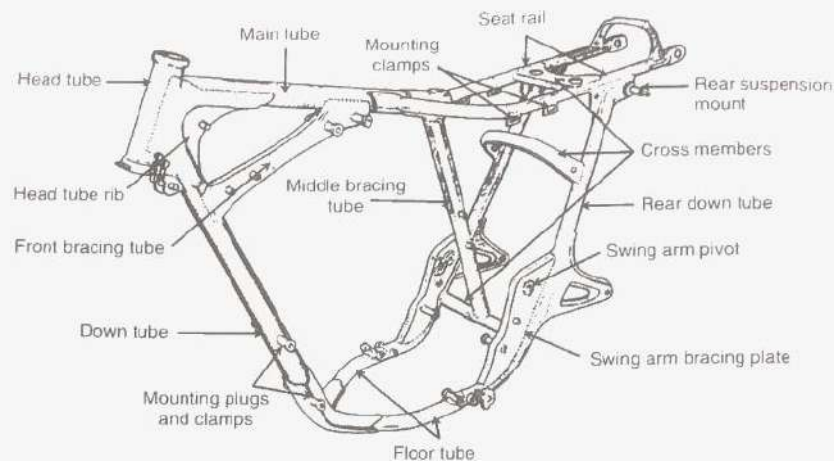
The double beam frame includes two main tubes, which wrap around the engine from the top. The multi-cylinder engine occupies more space and requires proper mounting. Therefore, in double beam frame, the engine is covers and supported from all sides. Increased number of cross members also increases lateral stiffness of the frame. Consequently, the structural efficiency of this frame is far better than the backbone type frame. This frame is suitable for inline multi-cylinder engines.



Double beam type frame

3) Single cradle frame:

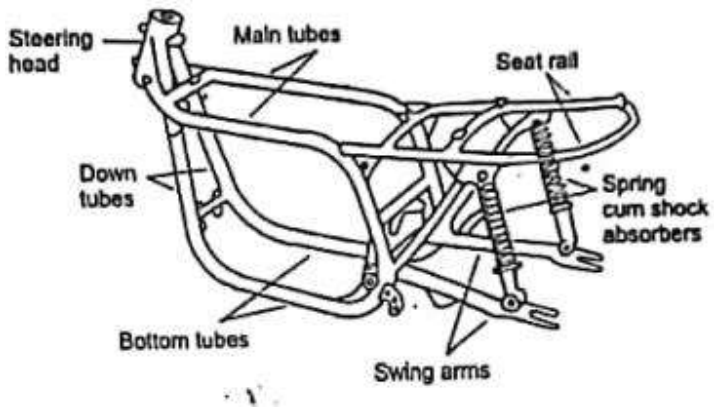
Along with main tube, this frame includes only one down tube to connect the steering head with the floor tubes. This construction gives less manufacturing cost when produced in mass scale. The diameter of the down tube is nearly similar to the main tube. It is the only connecting tube between the steering head and floor tubes. This frame is generally used on small capacity motorcycles and provides easy engine maintenance. Moreover, this frame is best suitable for vertical single cylinder engines.



Single Cradle Frame

4) Double cradle frame:

The double cradle design is similar to the above mentioned single cradle frame, but has two down tubes, resulting in increased rigidity. On some frames, a part of the down tube can be removed to facilitate easy engine removal. This frame is mainly used on large capacity mass produced motorcycles. Moreover, this frame is best suitable for horizontal and inclined single cylinder engines.



Double Cradle Frame.

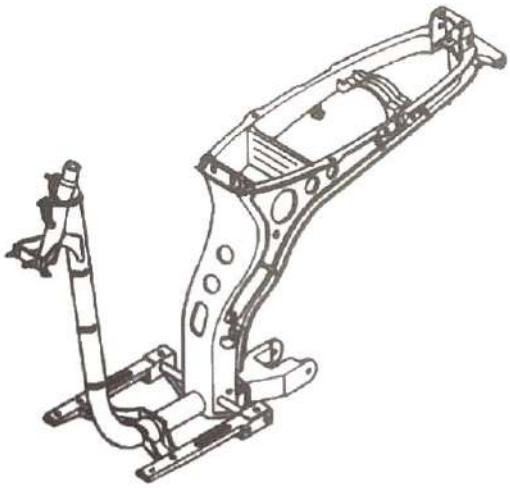
5) Trellis frame:

It is using to mounting a bigger engine in a tubular frame. The trellis frame uses wrapping tubes around the engine, and is known as girders. These girders are formed with the help of necessary triangulations. There is no down tube and floor tubes; therefore, engine is suspended through the tubed girders. This frame gives extremely lightweight and evenly rigid construction. Because of lightweight, the trellis frame gives good cornering characteristics. Moreover, this frame is best suitable for V-twin engines

6) Step-through frame:

This type of frame is a combination of pressed steel plates and steel tubing. This frame design is mainly used on scooters. This frame does not include any straight tube like backbone. The tube from the steering head is curved downward and welded to the main steel plate structure.

This arrangement is specially designed for the female riders to facilitate easy step-up and step-down to drive the vehicle. The engine is mounted at rear under the seat rails. The main structure supports the whole vehicle. Front tubing is welded to this main structure for mounting the steering system and front body panel.



Step-through frame

ENGINE-BASED FRAME

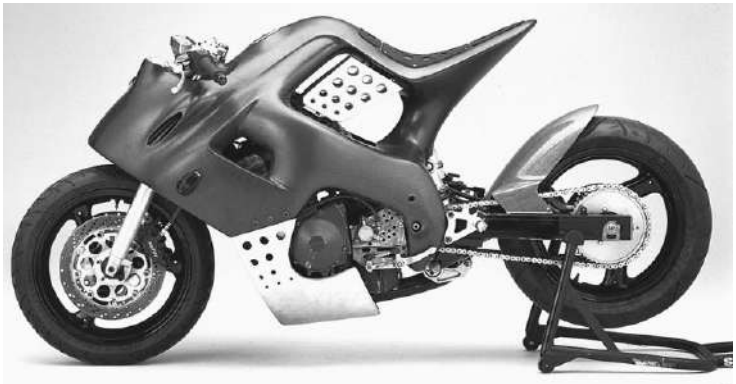
This is the most efficient way to build a two wheeler with a large engine. This frame use the integral stiffness of the engine gearbox unit to provide the major support between the steering head and the swing arm pivot. If that pivot is incorporated in the rear of the gearbox casting, then a simple lightweight structure will usually be sufficient to join the steering head to the top of the engine. The swing arm pivot is either clamped between aluminium alloy plates or mounted at the back of the gearbox. The engine cylinder heads are either attached to the backbone or mounted on the wrapping tubes. The most complicated part of this structure is the rear frame for mounting the seat and rear suspension unit. This design helps to reduce machine's weight

TWIN-SPAR FRAME

Modern large engines and their huge air boxes present a great challenge to the frame designer and the twin-spar offers considerable packaging advantages. It comprises of two beams running each side of the engine and gearbox unit, joining the steering head to the swing arm pivot mountings. These side beams may be extruded tubes, fabricated from steel or casted with aluminium alloys. Castings of aluminium alloys have often been used for the head stock area and the swing arm and rear engine mounting plates. These castings are welded to the side spars. The rear frame is usually bolted to the front frame, which is either made of steel tube or casted from the aluminium alloys. This type of frame allows much easier access to work on the engine, in particular, removal and replacement of carburetors or FI system and access to spark plugs. The elimination of down tubes and the lower cradle also facilitates space in the area needed by exhaust and cooling systems.

MONOCOQUE FRAME

This unique design uses a structure which provides necessary rigidity and smooth outer shape. There is no separate frame kind of construction to support the engine and other systems. The engine and other systems are directly mounted on the load bearing structure like a car. The structure may be fabricated from metal sheets or casted from aluminium alloys. Latest technique for racing motorcycles uses lightweight carbon fiber structure to serve this purpose.



Monocoque frame

FRAME MATERIAL

Steel: is easily the most common material used for frame fabrication. Depending on design, the frame is fabricated either as tube or sheet. Raw material cost is relatively low. Well-developed operating and joining techniques are available. Required stiffness can be obtained with small tube sizes.

Aluminium has often been used for specials and racing machines in the form of monocoques and large section backbones. However, components such as complete frames are rarely cast because the minimum material thickness needed for the casting process usually results in excessively heavy components. The use of aluminium alloy fabricated twin-spar frames is almost universal. Aluminium has limited life. For touring machines, where long life is always favourable, the steel frame greatly replaces the aluminium even on the cost of weight.

Titanium: Tubular frames have also been tried with titanium. With its low weight and high strength. titanium is probably used to best advantage in a triangulated design. Its chief disadvantages are high cost and the sophisticated welding techniques required, but its corrosion resistance is excellent.

Magnesium: It has been used for backbone type frames. It has high cost, welding difficulties and limited life because of both fatigue and corrosion.

Composite materials: The use of composite materials such as *carbon fiber* and *Kevlar reinforced plastics*, is extensively used in Formula One racing. The monocoque style of chassis use composite materials. Another form of composite material that has been tried is *aluminium honeycomb.*

BODY WORK

For two wheelers, body panels give first momentary appearance. This includes front fairing or body panels, fuel tank, tail fairing, headlights, side lights, tail lights, ORVMS and sometimes exhausts, seats and wheels.

Basic purpose of body panels is to create an attractive appearance for a vehicle, to cover and protect various systems and components, to absorb part of energy during collision and to provide aerodynamic shape for racing as well as touring vehicles.

Almost all two wheelers come with incredible curves and edges on body panels. Basically, curves and edges are used to create visual pleasure. The use of steel or aluminium for seats, mudguards, fairings etc. has been largely using in racing by reinforced plastics. Composite material is still stiffer than most other forms of construction. This enables thin and hence light weight panels and shapes to be molded, without undue flexibility in the finished component.

ERGONOMIC CONSIDERATIONS

From perspective of automobiles, *ergonomic refers to the ease with which the rider can operates and drive the vehicle*.

Ergonomic considerations plays important role when designing different systems of vehicle. As a result of good ergonomics, vehicle can be operated with optimal interaction between rider and vehicle itself.

The shaping and design of the seat along with the width and shape of the fuel tank also falls under the ergonomics. Optimum wind protection with a low level of wind noise is also important. Electrically operated height-adjustable windshields provide increased comfort. In the case of the sports motorcycles, the height and angle of the trim shield can also be adjusted. Many modern scooters are also equipped with height-adjustable seat for the rider. The principles of ergonomic design are considered in five different levels.

- First level: a vehicle must be safe for human beings.
- Second level: a vehicle must not produce harmful effects on human beings over longer periods.
- Third level: a vehicle must be physically comfortable
- Fourth level: a vehicle should provide mental satisfaction
- Fifth level: Determining the degree of innovation of a vehicle

Factors included in Ergonomic considerations

- Riding posture
- Driver's visibility
- Location of controls
- Seat design

1) Riding posture:

It includes the seating position of rider and passenger, also the height, texture and position of the handlebars and footrests.

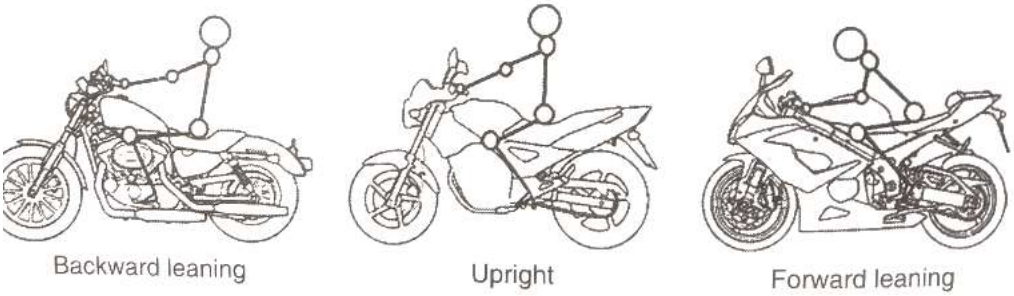
Fundamentally, there are three types of riding posture to drive a two-wheeler.

- Backward leaning
- Upright position
- Forward leaning.

Backward leaning posture is been preferred for touring machine. This posture gives more relaxed position if foot controls are mounted at the front of the engine. It provides extended legs towards front.

Upright position of the rider is preferred for the street and endure machines. This position helps to maintain the Center of gravity in the middle length of the vehicle, improving the handling characteristics.

Forward leaning does not do much to provide comfort. It only facilitates lesser drag and thus mostly used on sport and racing motorcycles.



2) Driver's visibility:

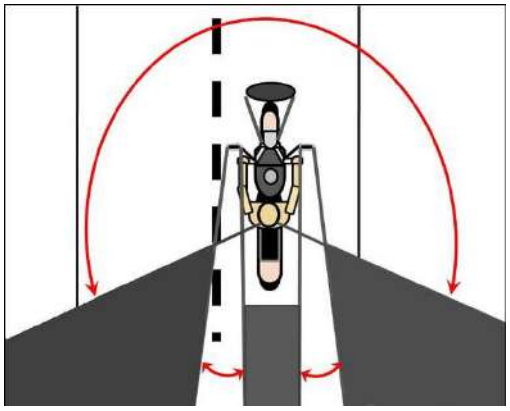
Rider's visibility is the maximum distance at which the rider of a vehicle can see and identify objects around the vehicle. Visibility is primarily determined by weather conditions and vehicle's design.

Blind spots may occur in the front of the vehicle.

Behind the rider, there are pillion passenger and goods that may reduce visibility.

Blind spots are the areas of the road and surroundings that cannot be seen while looking forward or through the rear view mirrors.

The area most commonly referred to as blind spots are the rear quarter blind spots, areas towards the rear of the vehicle on both sides.



3) Location of controls

It includes the position of hand levers and foot levers.

These locations primarily depend upon the riding posture. Various adjustments are provided depending upon the functional and space requirement. Modern vehicles are fitted with adjustable handlebar halves. The handlebar can be adjusted as per convenience of the rider. The handlebar controls facilities easy operation of hand levers for clutch and brake. Warm hands are also a part of feeling good on a motorcycle. They increase the concentration and increase safety. Therefore, some bikes are available with handlebar grips.

Location of foot pegs and foot levers should be decided according to riding posture and position of handle grips. Some adjustments are provided at foot pegs for the rider and the passenger.

4) Seat

Vehicle ride comfort is one of the most important factors affecting customer satisfaction. Normally rider feels different vibrations from seat surface, feet region and handle bar during driving and due to such type of vibration driver feels discomfort.

The two-wheeler seat have multiple shape that provide a static seating comfort for various riding positions of the vehicle. Body pressure distribution is influenced by personal attribute of the rider.

To provide maximum ride comfort and to damper the vibrations, two-wheeler seats are fabricated with different layers of foams

Seat construction

A hard plastic base forms the frame structure for the seat and used to hold the upper structure. *The variable density foam* is attached to the plastic base. This form is used to provide primary cushioning effect as the density of this foam can be changed according to loading conditions. *The shock absorbing synthetic gel* absorbs the vibrations coming through the frame. The gel is necessarily a mixture of chemical agents which do not react chemically with other materials of seat. *The heat resisting foam* prevents the heat flow toward the shock absorbing gel. The heat flow may take place from the atmosphere or from heating filament of the seat. This whole bunch of foam and gel is then covered with the help of a *soft cover,* which protects the internal components as well as provides secondary cushioning effect.

After all, the shape of seat also plays vital role in ergonomics because not only the absolute height of the seat determines whether the rider reaches the ground comfortably with both feet when standing, but also the shape and width, especially of the front section.

WHEELS AND TYRES

The importance of wheels and tyres in the two wheeler is obvious. Without engine the vehicle may be moved, but that is not possible without wheels and tyres. The wheel, along with the tyre had to take the vehicle load, provide a cushioning effect and cope with the steering control.

The various requirements of a wheel are

- It must be strong enough to perform the above function.
- It should be balanced both statically and dynamically.
- It should be lightest possible so that the unsprung mass is least.
- It should be possible to remove or mount the wheel easily.
- Its material should not deteriorate with weathering and age.

Wheel consists of two components, a **rim** and a **hub**. The wheel is then classified according to the way in which these both components are assembled

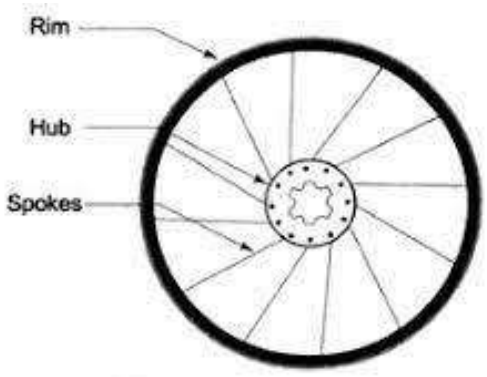
They are,

- **Spoked wheels (*Wire wheel*)**
- **Pressed steel wheels (*Disc wheel*)**
- **Alloy wheels**

Spoked wheel (wire wheel)

The spoked wheel has a separate hub, which is attached to the rim through a number of wire spokes. Each spoke is individually hooked at one end of the hub and the other end is connected to wheel rim. A nut is provided to pulling and tight the spokes.

The spoke carry the weight, transmit the driving and braking torque and withstand the side forces during cornering. *Spokes cannot take any compressive or bending stresses*. *Spokes carry all types of loads in tension*. The spokes are mounted in complicated criss-cross manner in all the three planes



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The advantages of spoked wheel are light weight and high strength. It provides much better cooling of the drum brake. It is very easy to change the wheel when required. However, spoked wheels are expensive. Further, it is not possible to fit tubeless tyres on spoked wheels because the rim of a spoked wheel has holes.

Pressed steel wheels (*Disc wheel*)

This type of wheel uses a steel disc to assemble the rim with the hub. The steel disc performs the functions of the spokes. The advantages of this type of wheel are simple construction, high strength, and tubeless tyre can be fitted to the pressed steel wheel. It is very easy to change the wheel when required. However, pressed steel wheels are expensive due to their fabrication.

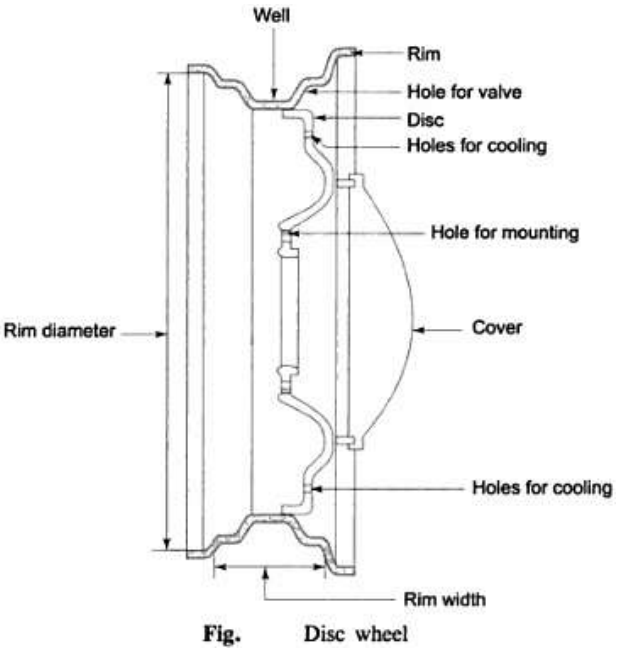


Fig. Disc wheel

They are heavier and provide less cooling when used with the drum brake. The unsprung mass considerably increases due to which cornering difficulties also increases. The suspensions are also required to be heavier with the extra laden mass of the pressed steel wheel

The pressed steel wheel is mostly used on scooters due to its simplicity, robust construction, and lower cost of manufacture and ease of cleaning. They required negligible maintenance and are easy to produce.

Wheel offset

Wheel offset is the distance from centerline of the rim and the attachment face of the disc.

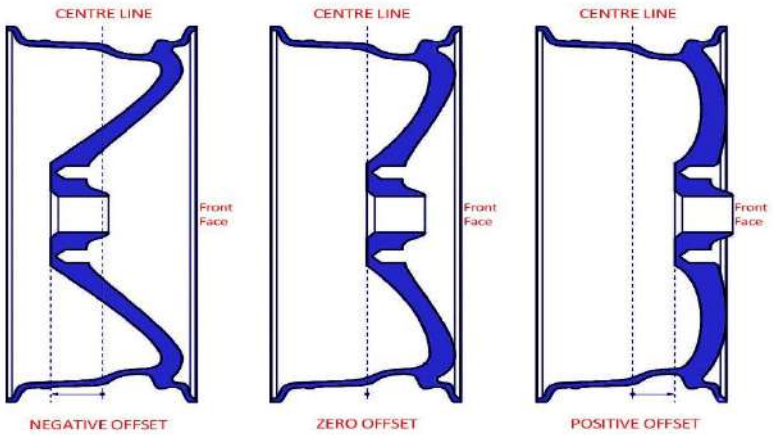
They are classified as

- Zero set
- Inset (positive offset)
- Outset (negative offset)

zero set: A zero set wheel is the one in which the rim centerline coincides with the attachment face of the disc

Inset: In the inset wheel the centerline of the rim is, located inboard of the attachment face of the disc. Inset is distance the distance from the attachment face of the disc to the centerline of the rim.

Outset: In the outset wheel the centerline of the rim is located outboard of the attachment face of the disc.



Alloy wheels

The alloy wheels are made from aluminium or magnesium alloys. The hub and rim is permanently attached through the ribs or arms. The main advantage of the light-alloy wheels is their low weight which reduces unsprung weight. Moreover, light alloys are better conductors of heat which helps the wheels to dissipate any heat generated by the tyres or brakes and thereby run cooler. Wider rims are possible in their case, which improves stability on cornering. They have high impact and fatigue strength so that they can stand vibrations and shock loading better. The protective coating areapplied on these wheels because alloys have tendency to corrosion. Higher cost is the only disadvantage of light alloy wheels.

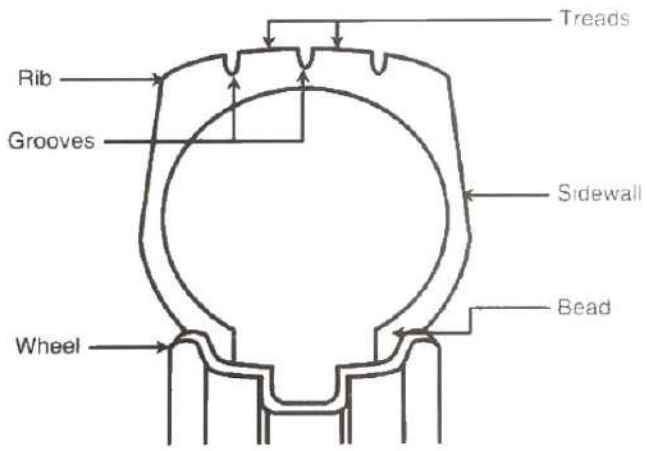
TYRES

The tyre is a flexible casing, which contains air. The friction between the tyre and the road determines the handling characteristics of any vehicle. A vehicle that handles poorly or that pulls, darts, jumps, or steers abnormally may be suffering from defective or worn tyres.

Tyres are mounted on wheels that are bolted to the vehicle to provide the following:

- Shock absorber action when driving over rough surfaces
- Friction (traction) between the wheels and the road

❖ Parts of a Tyre.



Tread: The part of tyre that contacts the ground. Tread rubber is chemically different from other rubber parts of a tyre, and is provided for a combination of traction and tyre wear. Wear indicators given on the treads are also called wear bars to gives indication about tyre wear.

Grooves: Grooves are large, deep recesses molded in the tread and separating the tread blocks. Grooves are provided to eliminate water traping around the tyre. The trapped water can actually cause the tyres to ride up on a layer of water and lose contact with the ground.

Sidewall: The sidewall is that part of the tyre between the tread and the wheel. The sidewall contains all the size and construction details of the tyre.

Bead: The bead is the foundation of the tyre and is located inside of the wheel rim. The bead is constructed of many turns of copper- or bronze- coated steel wire. The main body plies (layers of material) are wrapped around the bead.

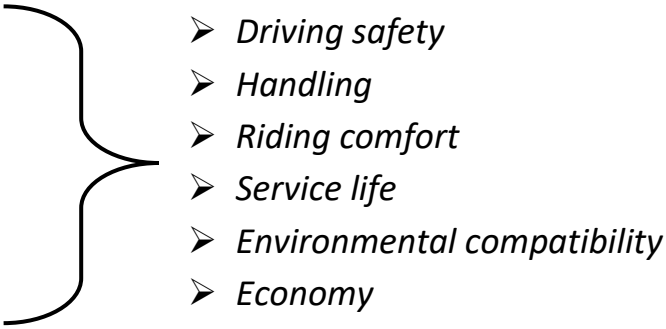
Body ply: This creates the main framework, or "carcass," of the tyre; these body plies are also called carcass plies and provides strength to the tyre.

Belt: A tyre belt is two or more layers of material applied over the body plies and under the tread area to stabilize the tread and increase tread life.

Inner liner: The inner liner is the soft rubber lining (usually a butyl rubber compound) on the inside of the tyre that protects the body plies and helps provide for self-sealing of small punctures.

❖ REQUIREMENTS OF TYRE

The requirements for tyres can be subdivided into six groups.



- *Driving safety*
- *Handling*
- *Riding comfort*
- *Service life*
- *Environmental compatibility*
- *Economy*

DRIVING SAFETY: To ensure driving safety it is essential that the tyre sits firmly on the rim. On the tubeless tyre this is the function of the inner lining. Its job is to prevent air escaping from the tyre. It stops the tyre from losing pressure.

HANDLING: Friction coefficient is an important factor. High friction coefficient in all operating conditions is always a desirable property of any tyre. The strength of sidewalls plays vital role in deciding the behaviour of the tyre under lateral forces. The tyre must possess good cornering stability during turning.

RIDING COMFORT: The riding comfort means good suspension and damping properties of tyre. Softer tyre gives more pleasant ride but provides less damping. Harder tyre damps the vibrations quickly but generates a jumpy ride.

SERVICE LIFE: The tyre is the first component, which remains loaded when vehicle is parked. The inflation pressure plays vital role during this loading conditions and finally affect the service life of the tyre. Frequent damage to the tyre may lead to accident. For a two-wheeler, the high-speed stability is also needed to increase the service life of tyre.

ENVIRONMENTAL COMPATIBILITY: The raw material must be easily disposable without affecting environment. Nowadays, re-moulding and re-treading are adopted to attain the lowest possible environmental issues.

ECONOMY: the purchase cost, travel range, wear rate, rolling resistance and load rating determine economic efficiency of tyre. These all factors determine the changeover time for the tyre. Longer changeover time gives maximum economy from customer point of view.

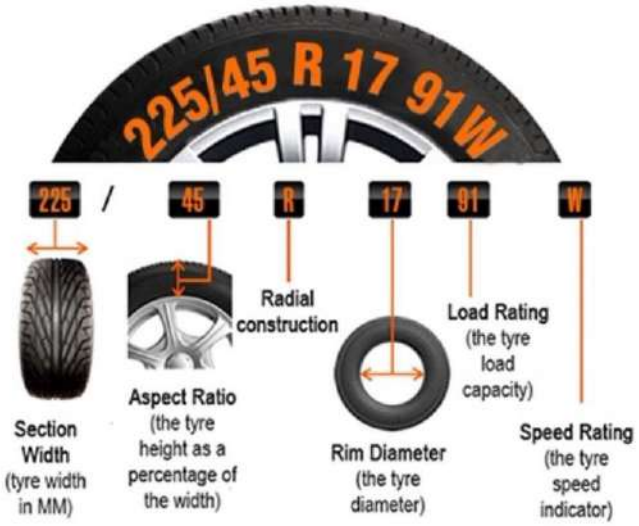
❖ Aspect ratios

Aspect ratio is the ratio of tire's height to its width. It is mentioned in percentages. If a tire has an aspect ratio of 70, it means the tire's height is 70% of its width.

$$\text{Aspect Ratio} = \frac{\text{Tyre Height}}{\text{Tyre width}}$$

❖ Designation of tyres

The first digit indicates the width of the tyre in mm. second digit indicates the aspectratio. The next letter indicated the type of carcass construction, i.e. either radial-ply or cross-ply. The next digit indicated the rim diameter in inches. The next two terms are covered in the bracket indicating the load index and speed rating respectively. In high performance tyres, the extra digits are added at the last to indicate the maximum speed above which the tyre should not be used.



TYPES OF TYRES

Tyres are classified into

- Tubed tyre
- Tubelless tyre

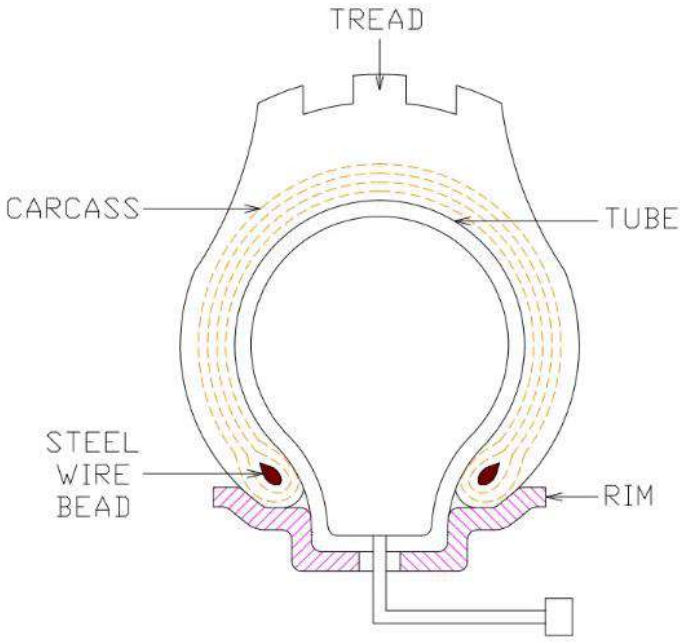
❖ Tubed tyre

It consists of the following parts

Rim : It is the steel material which is used to hold the tube and the tyre on it so that it can withstand the load of the vehicle. It has a hole on its circumference to allow the tube valve through it.

Tube : It is the material made of rubber and it consists of a valve which is pressurized by means of air so that it can bulge according to the need and can fit into the tyre properly. It has the disadvantage that, whenever there is a puncture then the air will be lost suddenly from the tube, tyre and the valve region also.

Tyre Thread : It is the material made up of rubber and acts as the major part of automobile. The power from the engine is to be transmitted to the wheels via axles such that the vehicle can move smoothly. It consists grooves on its circumference such that they can act as a friction between the road and the tyre.

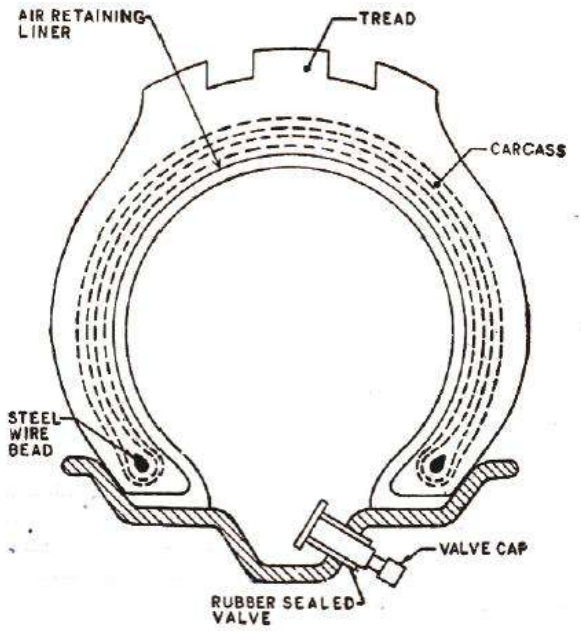


This type of tyre consist a rubber tube inside. The rubber tube contains the air under pressure and provides cushioning effect. The tube is very thin and flexible, takes up the shape of the tyre cover when inflated. A valve stem is attached to the tube for inflating or deflating. The tyre takes all loads during dynamic condition while tube with pressurized air provides suspension effect. A protective strip has to be used when this conventional type tyre is used on the spoked wheel because the end of the spokes inside the rim can damage the thin tube. In case of tubed tyre, heat in the compressed air has to be pass through the tube material. The unsprung mass increases due to the tube type construction, which also increases wheel bounce.

❖ Tubeless tyre

This type of tyre does not need separate tube. The air under pressure is filled in the tyre for which, a non-return valve is fitted to the rim. The tyre is directly mounted on the rim and retains the air. The inner construction of tyre is almost the same as that of tubed tyre, except that it is lined on inside with a special air-retaining liner. It consist of two main parts, ***carcass*** and ***tread***.

The carcass is basic structure taking mainly the various loads and consists of a number of piles wounded in a particular pattern. The tread is a part of tyre, which comes in contact with the road surface when the wheel rotates. It is generally made of synthetic rubber. The design of tyre treads depends on various tyre properties like grip, noise and the wear. Between the bead and the tread, sidewall is provided which is an outer rubber covering. At the inner edges, beads are formed by reinforcing with steel wires. All piles are tied to the beads, which prevent any change of shape.



Advantages

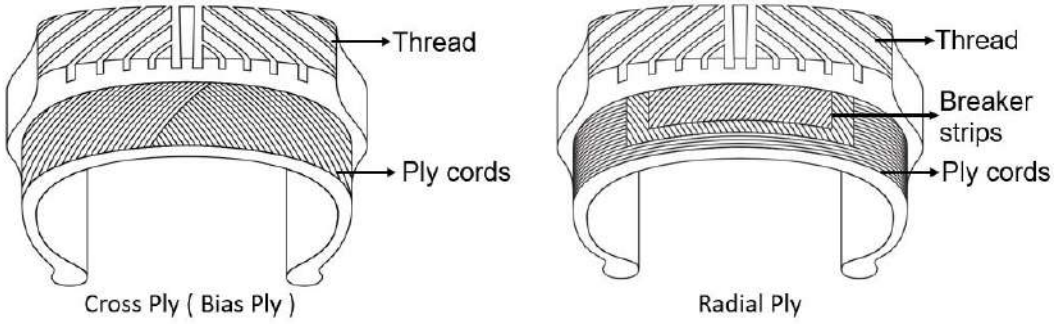
- Lesser unsprung weight due to lack of tube weight, So increase fuel efficiency.
- Better cooling hence there is no tube heat directly transferred to rim
- Shocks & vibration absorbed effectively which increase driving comfort.
- Slower Leakage of air in case of puncture
- In case of puncture, air defuses slowly which provide Improve road safety.

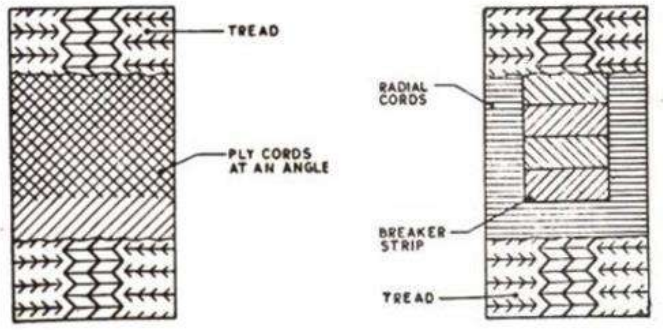
❖ Carcass

Carcass is the Skelton or main structure of a tyre. They are classified as

- **Cross Ply (Bias Ply)**
- **Radial Ply**
- **Belted – Bias ply**

Cross-ply tyres: This is a non-radial type carcass. In this type, the plies are layered diagonal from one bead to the other bead at about a 30° angle. One ply is set on a bias in one direction ans succeeding plies are set in opposing directions as they cross each other. The ends of the plies are wrapped around the bead wires and anchoring them to the rim of the wheel. Figure shows the interior structure and the carcass arrangement of a non-radial tyre.





Cross Ply (Bias Ply) Radial Ply

Radial Ply : In this the ply cords run in the *radial direction*. Breaker strips are provided over the plys in the *circumferential direction*. It provides the directional stability. The material of breaker strip is flexible. In radial tyre, the sidewall flexes more easily under the weight of the vehicle. So, more vertical deflection is achieved with radial tyres. As the sidewall flexes under the load, the belts hold the tread firmly and evenly on the ground and reduces tread scrub. Radial tyres are the preferred tyre in most applications today.

Belted bias Ply : This is a combination of cross ply and radial ply. In this type the ply cords are arranged diagonally and breaker strips are provided over it. The breaker strips hold the thread flatter against the road surface and it increases the resistance of thr tyre against puncture.

Comparison of Radial ply, Cross ply and belted bias ply tyres

Sr No.	Radial ply tyre	Cross ply tyre	Belted bias tyre
1	Plies are running radially straight from bead to bead	Piles are running diagonally opposite from bead to bead.	The basic construction is like the bias-ply but for strengthening belt plies are added in the tread area the cord in belt run at an angle of 20° to 35° to the centre line of tire tread
2	Stiffness of tyre is less, so it gives ultimate comfort at high speed.	Stiffness of tyre is more, so less comfortable.	Stiffness of tyre is moderate
3	Steering is harder.	Steering is easy.	Steering is moderate
4	Tyre has firm grip with road.	Tyre has lesser grip with road.	holds the tyre flatter thus provides good grip and safety
5	Radial ply tyre has more tread life.	Cross ply tyre has less tread life.	Belted bias tyre has more life than radial & cross ply tyres
6	More braking grip.	Less braking grip.	More braking grip
7	Costlier than cross ply tyre	Cheaper than radial ply tyre.	Costlier than radial ply & cross ply tyre

❖ Tyre inflation pressure

Tire inflation pressure is the amount of air inside a tire recommended by a vehicle manufacturer. This inflation pressure or air pressure is measured by PSI or bar, using a tire pressure gauge.

The inflation pressure of tires before a car is driven and the tyres warmed up is known as Cold inflation pressure. Recommended air pressure offer benefits like extended tire life, optimum driving safety, and improved fuel efficiency.

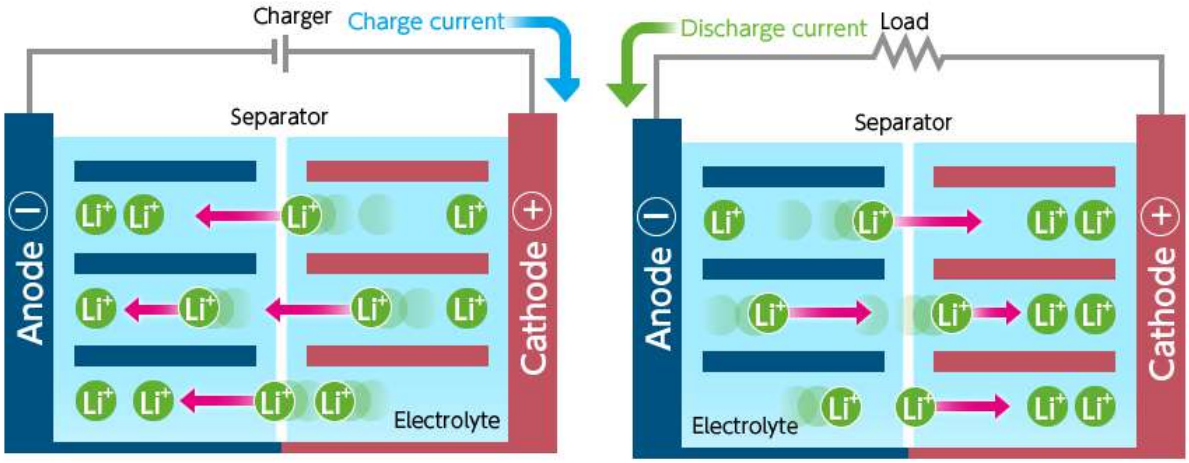
As highlighted above, the inflation pressure has a direct impact on tire performance. The fluctuation in tire pressure can make a ride stiffer or rougher.

When the tires are ***underinflated***, there's an increase of treadwear on the *outer edges* along with an excessive generation of heat. It also leads to more fuel consumption as the rolling resistance of underinflated tires is higher.

Overinflated tires, on the other hand, put more of the vehicle's weight on the center tread, causing faster wear and uneven wear at *center* portion.

LITHIUM-ION BATTERY

The lithium-ion battery is made of one or more cells. Each cell has positive electrode, negative electrode and electrolyte.



The positive electrode is typically made from lithium-cobalt oxide (LiCoO2) or lithium iron phosphate (LiFePO4). The negative electrode is generally made from carbon (graphite). The electrolyte varies from one type of battery to another.

The electrolyte carries positively charged lithium ions from the anode to the cathode. The movement of the lithium ions creates free electrons in the anode which creates a charge at the positive current collector. The electrical current then flows from the current collector through a device being powered to the negative current collector.

While the battery is discharging and providing an electric current, the anode releases lithium ions to the cathode, generating a flow of electrons from one side to the other.

Advantages of Lithium Ion battery

- High energy density
- Long lifespans
- long-term performance
- Fast charge times
- Low self-discharge
- Temperature tolerant

Battery Management System

Battery management system are electronic control circuit that monitor and regulate charging and discharging of batteries. The aim of battery management system is to ensure the optimal use residual energy present in battery. This system protect the batteries from deep discharging and over charging.

Functions

- Control charging of the battery, with no overcharging, to ensure a long life of the battery.
- Monitor the discharge of the battery to prevent damage inflicted on the battery by interrupting the discharge current when the battery is empty.
- Keep track of the battery's SoC and use the determined value to control charging and discharging of the battery and signal the value to the user of the portable device.
- Power the load with a minimum supply voltage, irrespective of the battery voltage, using DC/DC conversion to achieve a longer run time of the portable device