ME5691
BASIC AUTOMOBILE ENGINEERING

UNIT-1
INTRODUCTION

by

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AUTOMOBILE

Automobile engineering is the one of the stream of mechanical engineering. It deals with the various types of automobiles, their mechanism of transmission systems and its applications. Automobiles are the different types of vehicles used for transportation of passengers, goods, etc. Basically all the types of vehicles works on the principle of internal combustion processes or some times the engines are called as internal combustion engines. Different types of fuels are burnt inside the cylinder at higher temperature to get the transmission motion in the vehicles. Most of the automobiles are internal combustion engines vehicles only. Therefore, every mechanical and automobile engineers should have the knowledge of automobile engineering its mechanism and its various applications.

CLASSIFICATION OF VEHICLES

Automobiles or vehicles can be classified on different bases as given below :

On the Basis of Load

(a) Heavy transport vehicle (HTV) or heavy motor vehicle (HMV), e.g. trucks, buses, etc.
(b) Light transport vehicle (LTV), e.g. pickup, station wagon, etc.
(c) Light motor vehicle (LMV), e.g. cars, jeeps, etc.

Wheels

(a) Two wheeler vehicle, for example : Scooter, motorcycle, etc.
(b) Three wheeler vehicle, for example : Autorickshaw, three wheeler scooter for handicaps and tempo, etc.
(c) Four wheeler vehicle, for example : Car, jeep, trucks, buses, etc.
(d) Six wheeler vehicle, for example : Big trucks with two gear axles each having four wheels.

TYPES

Body

On the basis of body, the vehicles are classified as :

(a) Sedan with two doors

(b) Sedan with four doors

(c) Station wagon

(d) Convertible, e.g. jeep, etc.

(e) Van

(f) Special purpose vehicle, e.g. ambulance, milk van, etc.

TYPES

Fuel Used

(a) Petrol vehicle, e.g. motorcycle, scooter, cars, etc.
(b) Diesel vehicle, e.g. trucks, buses, etc.
(c) Electric vehicle which use battery to drive.
(d) Steam vehicle, e.g. an engine which uses steam engine. These engines are now obsolete.
(e) Gas vehicle, e.g. LPG and CNG vehicles, where LPG is liquefied petroleum gas and CNG is compressed natural gas.

COMPONENTS

The automobile can be considered to consist of five basic components :

(a) The Engine or Power Plant : It is source of power.

(b) The Frame and Chassis : It supports the engine, wheels, body, braking system, steering, etc.

(c) The transmission which transmits power from the engine to the car wheels. It consists of clutch, transmission, shaft, axles and differential.

(d) The body.

(e) Accessories including light, air conditioner/hearer, stereo, wiper, etc.

Chassis and Frame

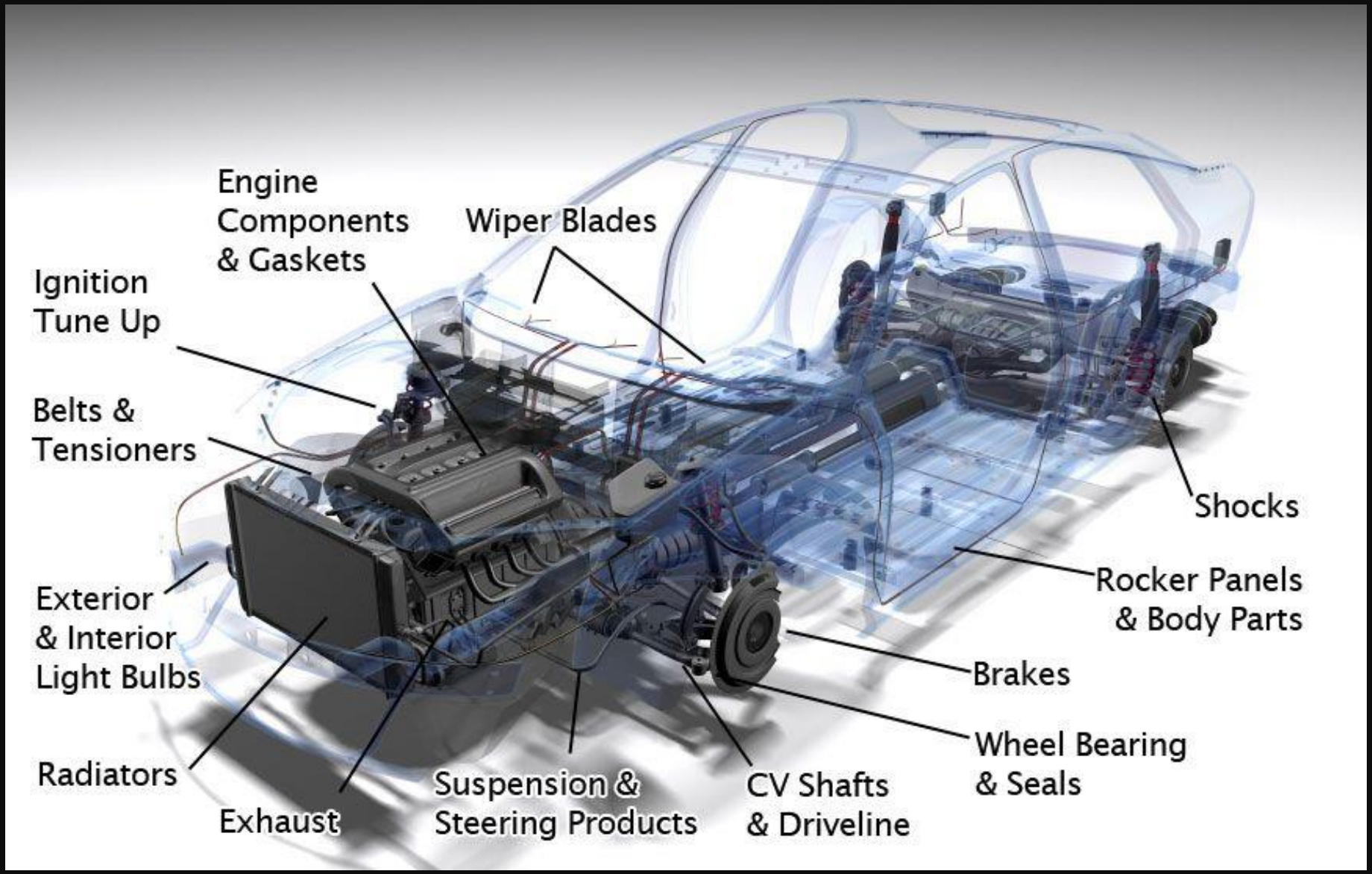
The chassis is formed by the frame with the frame side members and cross members. The frame is usually made of box, tubular and channel members that are welded or riveted together. In addition to this, it comprises of the springs with the axles and wheels, the steering system and the brakes, the fuel tank, the exhaust system, the radiator, the battery and other accessories. Along with this the frame supports the body.

Engine or Power Plant

The engine is the power plant of the vehicle. In general, internal combustion engine with petrol or diesel fuel is used to run a vehicle. An engine may be either a two-stroke engine or a four-stroke engine. An engine consists of a cylinder, piston, valves, valve operating mechanism, carburetor (or MPFI in modern cars), fan, fuel feed pump and oil pump, etc.

Besides this, an engine requires ignition system for burning fuel in the engine cylinder.

COMPONENTS


Engine
Components
& Gaskets
Wiper Blades
Ignition
Tune Up
Belts &
Tensioners
Shocks
Rocker Panels
& Body Parts
Exterior
& Interior
Light Bulbs
Brakes
Wheel Bearing
& Seals
Radiators
Exhaust
Suspension &
Steering Products
CV Shafts
& Driveline

COMPONENTS

Transmission System (Clutch and Gear Box)

Clutch

The purpose of the clutch is to allow the driver to couple or decouple the engine and transmission. When clutch is in engaged position, the engine power flows to the transmission through it (clutch). When gears are to be changed while vehicle is running, the clutch permits temporary decoupling of engine and wheels so that gears can be shifted. In a scooter, the clutch is operated by hand where as in a car the clutch is operated by foot. It is necessary to interrupt the flow of power before gears are changed. Without a clutch, it will by very difficult.

Gear Box

Gear box contains gearing arrangement to get different speeds. Gears are used to get more than one speed ratios. When both mating gears have the same number of teeth, both will rotate at same number speed. But when one gear has less teeth than other, the gear with less number of teeth will rotate faster than larger gear. In a typical car, there may be six gears including one reverse gear. First gear gives low speed but high torque. Higher gears give progressively increasing speeds. Gears are engaged and disengaged by a shift lever.

Final Drive

Final drive is the last stage in transferring power from engine to wheels. It reduces the speed of the propeller shaft (drive shaft) to that of wheels. It also turns the drive of the propeller shaft by an angle of 90o to drive the wheels.

COMPONENTS

Braking System

Brakes are used to slow down or stop the vehicle. Hydraulic brakes are generally used in automobiles, where brakes are applied by pressure on a fluid. Mechanical brakes are also used in some vehicles. These brakes are operated by means of leavers, linkages, pedals, cams, etc. Hand brake or parking brake is usually a mechanical brake. These are used for parking the vehicles on sloppy surfaces and also in case of emergency.

Steering System

In front wheels can be turned to left and right by steering system so that the vehicle can be steered. The steering wheel is placed in front of driver. It is mechanically linked to the wheels to provide the steering control. The primary function of the steering system is to provide angular motion to front wheels so that vehicle can negotiate a turn. It also provides directional stability to vehicle when the vehicle moves ahead in straight line.

Now-a-days, many vehicles are equipped with power steering which uses pressure of a fluid to reduce steering effort. When driver turns the steering wheel, a hydraulic mechanism comes into play to provide most of the effort needed to turn the wheel.

COMPONENTS

Front Axle

Front axles are mounted at the end of front axle. A part of the weight of vehicle is transmitted to the wheels through this axle. The front axle performs several functions.

It carries the weight of the front of the vehicle and also takes horizontal and vertical loads when vehicle moves on bumpy roads. When brakes are provided on front wheels, it endures bending stresses and torsional stresses. It is generally made from steel drop forging. It is robust in construction.

Suspension System

Suspension system of an automobile separates the wheel and axle assembly of the automobile from its body. Main function of the suspension system is to isolate the body of the vehicle from shocks and vibrations generated due to irregularities on the surface of roads. Shock absorbers are provided in the vehicles for this purpose.

It is in the form of spring and damper. The suspension system is provided both on front end and rear end of the vehicle. A suspension system also maintains the stability of the vehicle in pitching or rolling when vehicle is in motion.

CHASSIS

Chassis

Chassis is the most important part of a vehicle and only fewer people care about it. Chassis contains all the major parts to propel the vehicle, direct its movement, stop it, and also run smoothly over uneven surfaces. It is also known as a carrying unit because all of the components are mounted on it including the body.

Functions of the chassis

The functions of the chassis includes

- carrying the weight of the vehicle and its passengers,
- withstanding the engine and transmission torque and thrust stresses, as well as accelerating and braking torque
- withstanding the centrifugal force while taking a turn and
- withstanding the bending load and twisting due to the rise and fall of the front and rear axles.

General consideration Relating to chassis

Body of most vehicle should fulfil the following requirements:

1. The body should be light.
2. It should have minimum number of components.
3. It should provide sufficient space for passengers and luggage.
4. It should withstand vibrations while in motion.
5. It should offer minimum resistance to air.
6. It should be cheap and easy in manufacturing.
7. It should be attractive in shape and colour.
8. It should have uniformly distributed load.
9. It should have long fatigue life
10. It should provide good vision and ventilation.

Classification Chassis acc to layout

- Conventional
- Semi-forward
- Full-forward

Explain the Automobile Chassis?

Automobile Chassis

→ **Semi-forward Chassis**

- Half Engine fitted inside Driver's Cabin and Remaining half in the front of Driver's Cabin

Keywords

- *Internal Framework*
- *Frame Supporting the Vehicle*
- *Major Units*
- *Propelling and Controlling*

AUTOMOBILE CHASSIS is defined as the *Internal Framework* which consists of a *Frame Supporting the Vehicle* and all the *Major Units* responsible for *Propelling and Controlling* of the Vehicle.

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Chassis Classification Based on engine location

- Engine fitted at front
- Engine fitted at Back
- Engine fitted at centre

FITTED AT FRONT & DRIVE IS GIVEN TO THE WHEELS FROM THE "REAR"

1. *Enough space is available for luggage behind the rear seat*
2. *The weight of vehicles is well balance*
3. *Increased efficiency of cooling system*

Engine is fitted at front & drive is given to front wheel

1. *Low floor is available.*
2. *Vehicle has more road holding capacity.*
3. *clutch , gear box & differential are usually made as one unit, thereby cost is reduced.*

Engine fitted at the centre of the chassis:

- Drive is given to the rear
- As in royal tiger world master buses
- This arrangement provide full space of floor for use

ENGINE FITTED AT BACK

1. Flat floor is available since long propeller shafts are eliminated
2. With elimination of propeller shaft the centre of gravity lowered giving stable driving
3. Better adhesion on road specially when climbing hill.
4. While Climbing hills proper adhesion may be affected since the weight of vehicles moves to the rear , thereby reducing the weight on the front wheel.
5. As a result of grouping of the engine with clutch, gear box and differential, the repair and adjustment become difficult due to congestion at the rear.

FRAMES

TYPES OF CHASSIS FRAMES:

THERE ARE THREE TYPES OF FRAMES

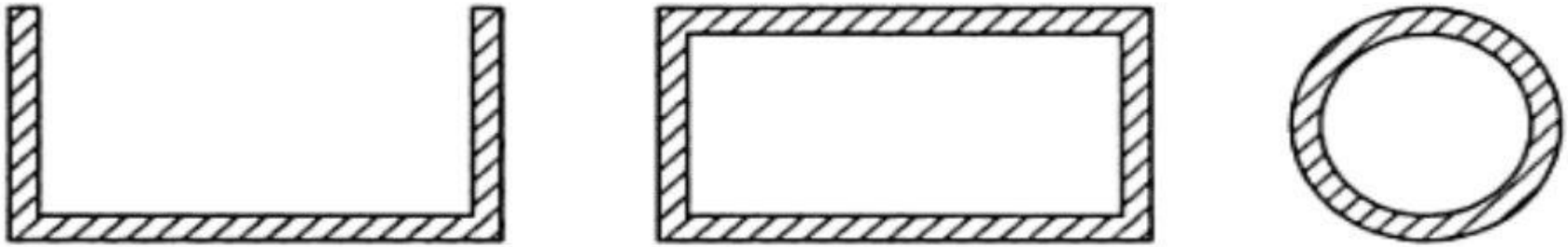
1. CONVENTIONAL FRAME
2. INTEGRAL FRAME
3. SEMI-INTEGRAL FRAME

CONVENTIONAL FRAME

a.Channel Section - Good resistance to bending

b. Tabular Section - Good resistance to Torsion

c. Box Section - Good resistance to both bending and Torsion



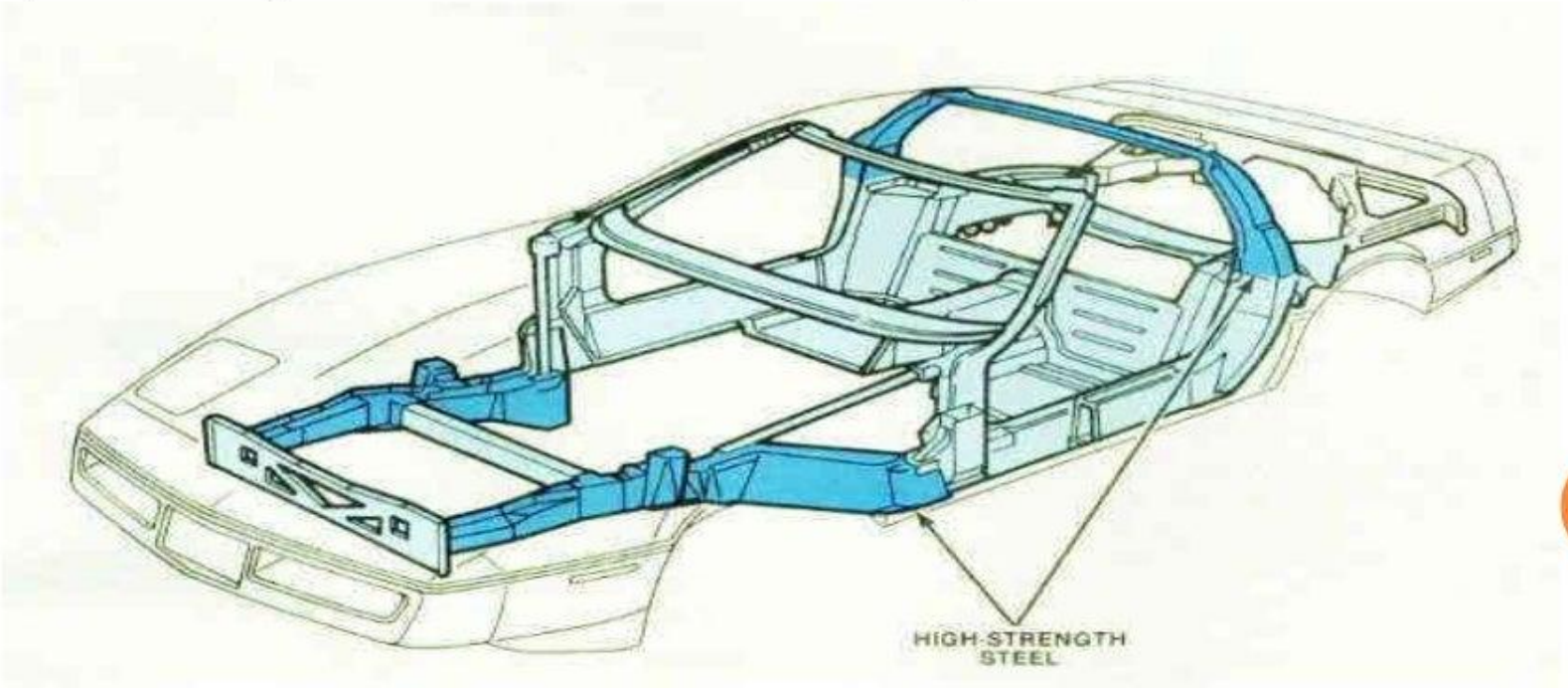
Steel sections used in chassis frame.

Integral Frame (Frameless)

- used now a days in most of the cars
- no frame and all the assembly units are attached to the body
- Due to elimination of long frame it is cheaper
- Only disadvantage is repairing is difficult.

Semi - Integral Frame

- half frame is fixed in the front end on which engine gear box and front suspension is mounted.
- It has the advantage when the vehicle is met with accident the front frame can be taken easily to replace the damaged chassis frame.
- <u>This type of frame is used in FIAT cars and some of the European and American cars.</u>



Some of important Chassis Frames are:

- Ladder Frame
- Tabular Space Frame
- Monocoque Frame
- Aluminum Space Frame
- Carbon Fibre frame

LADDER FRAME:

- The ladder frame is the simplest and oldest of all designs.
- This design offers good beam resistance because of its continuous rails from front to rear
- poor resistance to torsion

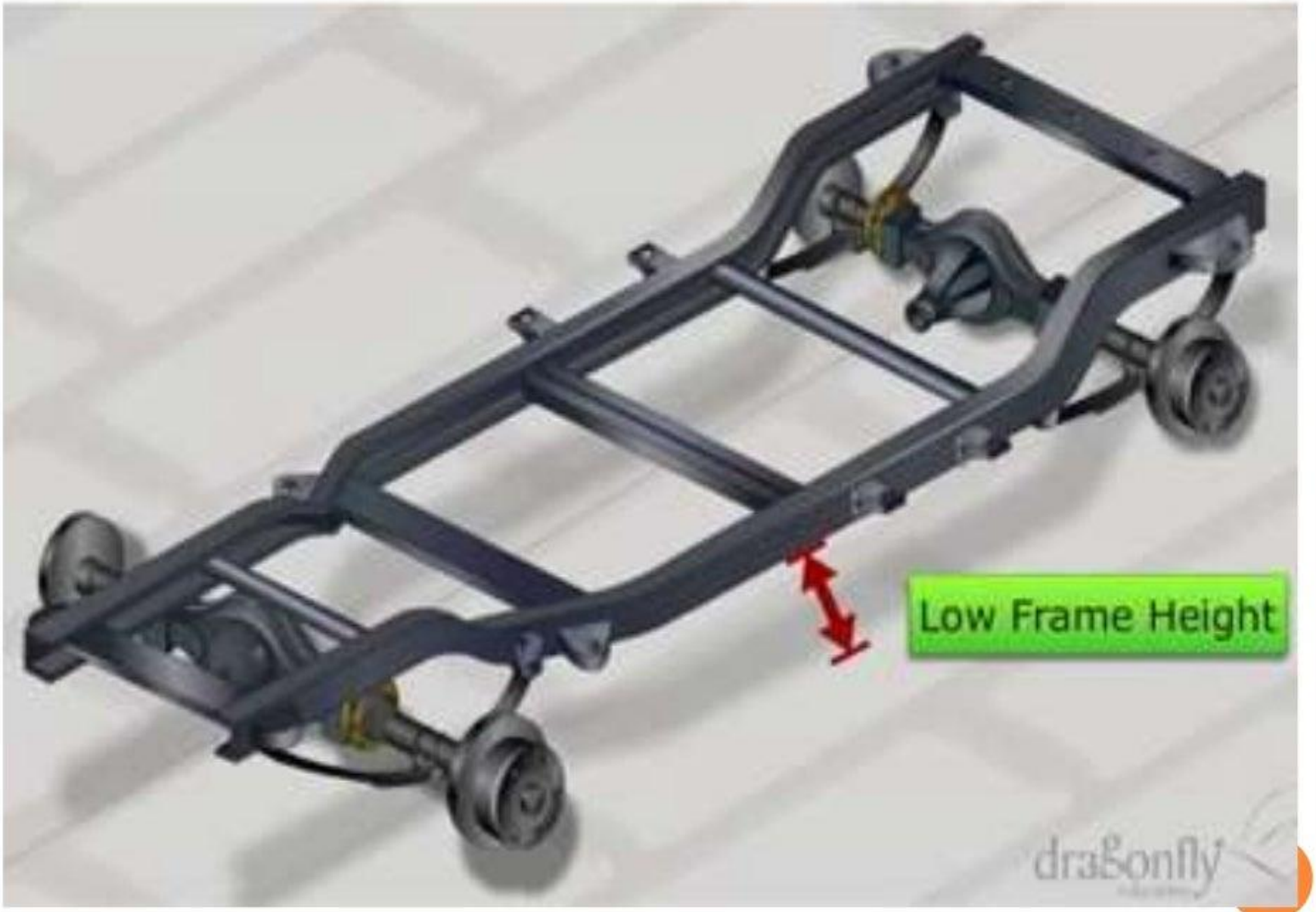
Chassis Frame

A type frame

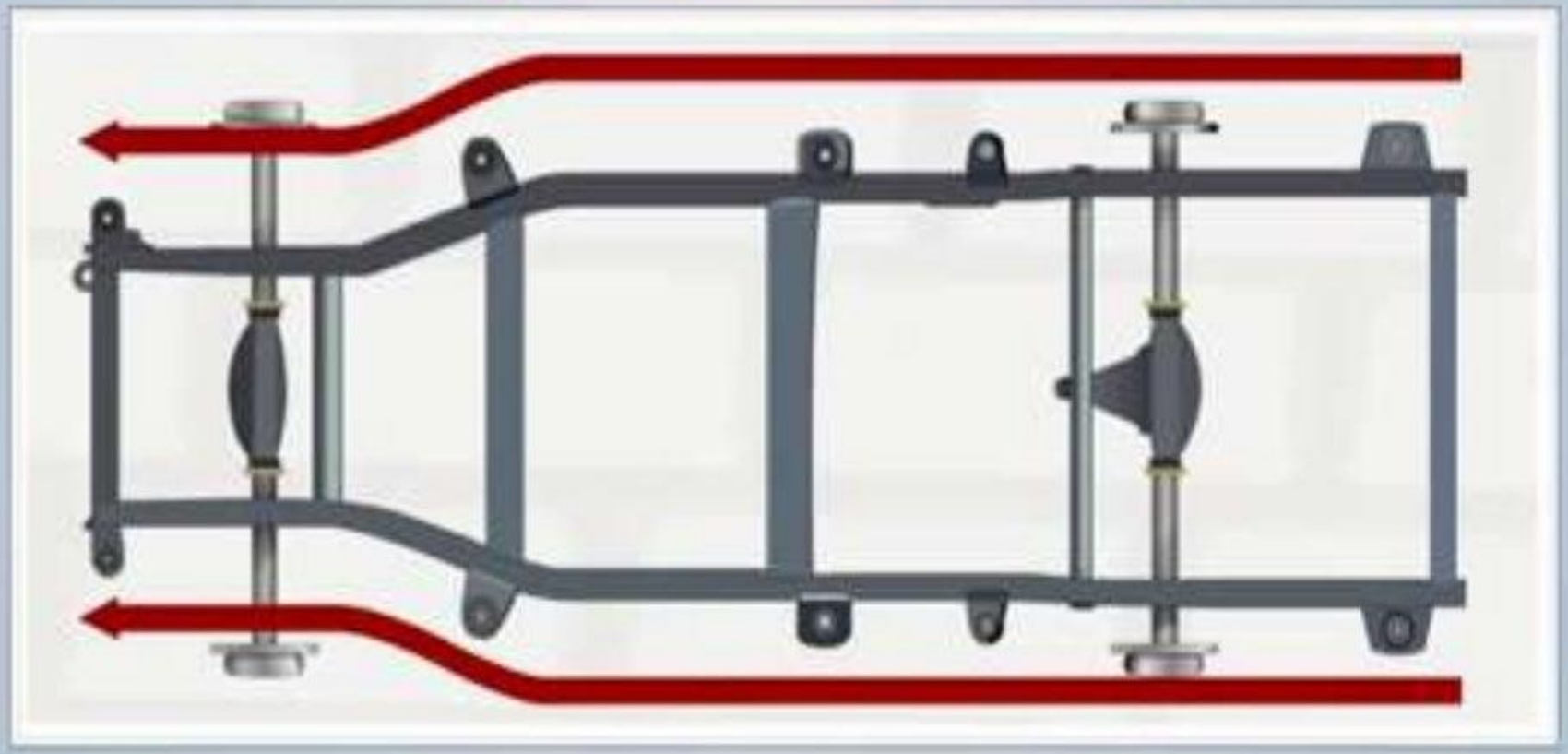
X type frame

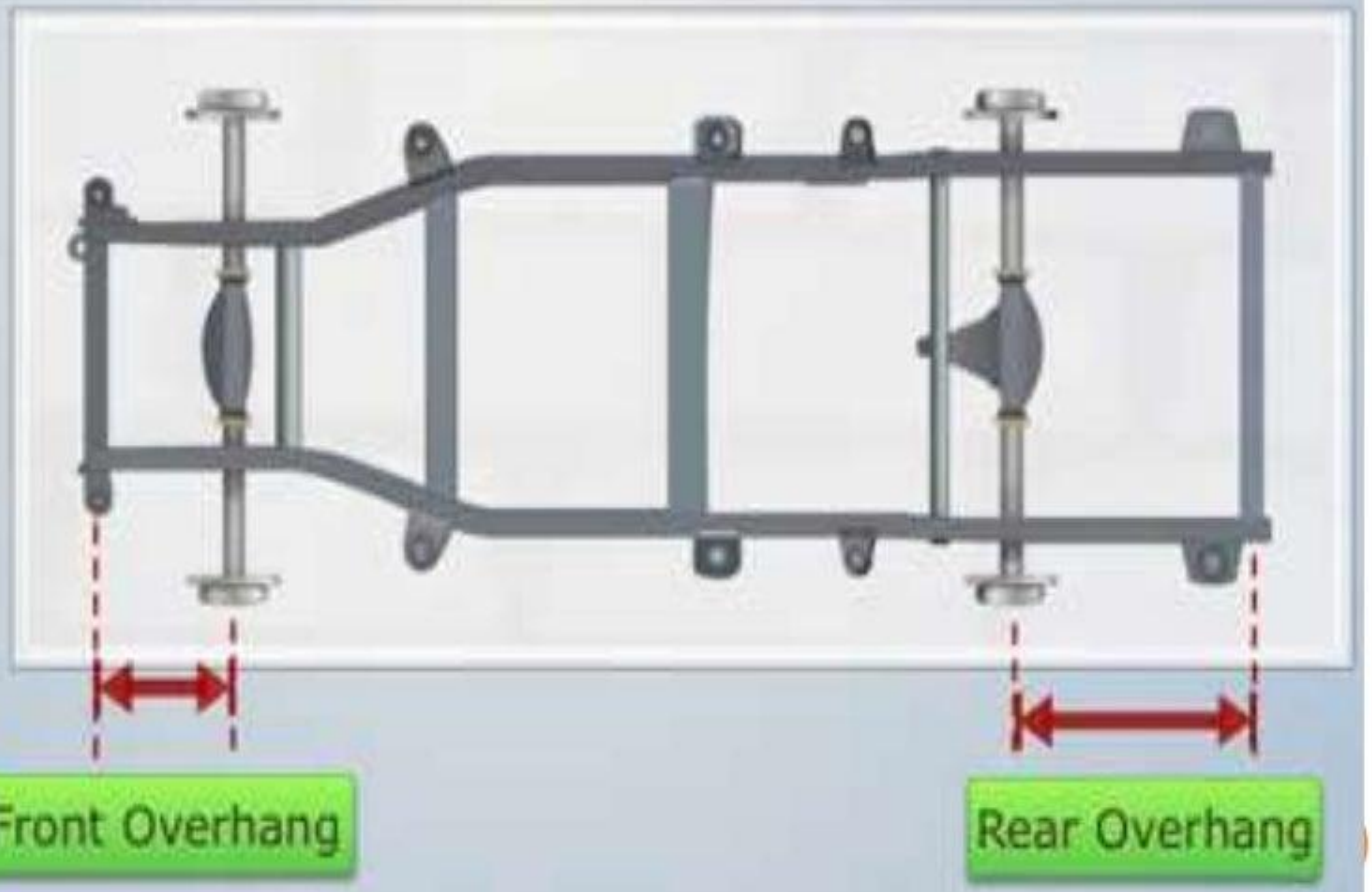
High torsional rigidity

Springing Space


Low Frame Height
dragonfly

To Provide Better Steering Lock




Front Overhang
Rear Overhang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TUBULAR SPACE FRAME:

- It is 3-dimensional design
- Tubular space frame chassis employs dozens of circular, rectangular etc section tube, positions in different directions to provide mechanical strength against force from anywhere.
- These tubes are welded & forms a very complex structure.

TUBULAR

ADVANTAGES

- Very strong in any direction (compared with ladder chassis and Monocoque chassis)

DISADVANTAGES

- Very complex , costly and time consuming to be built.

MONOCOQUE

- Monocoque is a one-piece structure which defines overall shape of the car. while ladder , tabular & backbone provide only stress members
- Today 99% car produced in this planet are made of Monocoque chassis.
- Chassis are made by welding of several pieces.(Spot winding).

Metal Monocoque

Carbon Fibre Monocoque

MONOCOQUE

DISADVANTAGES

1. It has very complex design .
2. Impossible for small volume production.

ADVANTAGES

1. *Space-efficiency (the whole structure is actually an outer shell.)*
2. *Monocoque chassis benefit crash (reproduction) production because it uses a lot of metal.*
3. *Cheap for mass production.*

Aluminium Monocoque-

- Audi A8 is the first mass production car featuring Aluminium Space Frame chassis.

- To replace conventional steel monocoque mainly for the benefit of lightness.
- Audi claimed A8's ASF is 40% lighter yet 40% stiffer than contemporary steel monocoque.

Advantage: Lighter than steel monocoque. As space efficient as it.

Disadvantage: Still expensive for mass production

Carbon-Fiber Monocoque

- Carbon Fiber is the most sophisticated material using in aircrafts, spaceships and racing cars because of its **superior rigidity-to-weight ratio**.
- Road cars featuring Carbon-Fiber body panels, such as Ferrari 288GTO and Porsche 959.There are several Carbon-fibers commonly used in motor industry.
- **Kevlar,** which was developed by **Du Pont**, offers the highest rigidity-to-weight ratio among them. Because of this, army's helmets are made of Kevlar. Kevlar can also be found in the body panels of many exotic cars, although most of them simultaneously use other kinds of carbon-fiber in even larger amount.

Carbon Fibre Monocoque

Production process

- Carbon-fiber panels are made by growing carbon-fiber sheets (something look like textile) in either side of an aluminium foil.
- The foil, which defines the shape of the panel, is sticked with several layers of carbon fiber sheets impregnated with resin, then cooked in a big oven for 3 hours at 120℃ and 90 psi pressure.
- After that, the carbon fiber layers will be melted and form a uni-formal, rigid body panel

Comparison Ladder and Monocoque

Performance -

- The monocoque is a lighter design which is a plus for fuel efficiency,
- It has more torsional stiffness and is by far the better chassis for performance oriented vehicles.
- The heavy nature of the ladder chassis makes it tough and it is much better than the monocoque for carrying heavy loads and towing heavier objects.

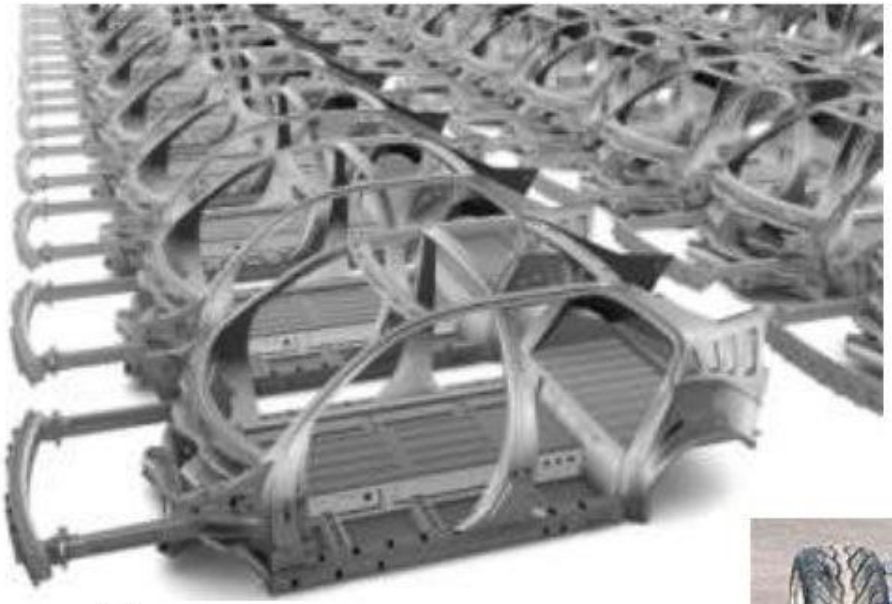
Design -

- A unibody bodyshell is difficult to design, build and modify (platform sharing) when compared to the body on frame but computer aided design (CAD) makes unibody platform sharing much easier.
- For body on frame vehicles its easy to build another body even from another bodystyle and place it on a ladder chassis as long as they are of similar dimensions.

Materials -

- Unitary bodyshells can be made from a variety of materials steel and steel alloys, aluminium and aluminium alloys and even carbon fiber or combinations of these materials whereas ladder chassis are usually built from steel.

A Quick Comparison



Monocoques

Typical Ladder Frame

VARIOUS LOADS ACTING ON THE FRAME:

1. Short duration Load - While crossing a broken patch.
2. Momentary duration Load - While taking a curve.
3. Impact Loads - Due to the collision of the vehicle.
4. Inertia Load - While applying brakes.
5. Static Loads - Loads due to chassis parts.
6. Over Loads - Beyond Design capacity.

AERODYNAMIC DRAG

Automotive Aerodynamics is the study of air flows around and through the vehicle body. More generally, it can be labelled “Fluid Dynamics” because air is really just a very thin type of fluid. Above slow speeds, the airflow around and through a vehicle begins to have a more pronounced effect on the acceleration, top speed, fuel efficiency and handling.

Influence of flow characteristics and improvement of flow past vehicle bodies

- Reduction of fuel consumption
- More favorable comfort characteristics (mud deposition on the body, noise, ventilating and cooling of the passenger compartment)
- Improvement of driving characteristics (stability, handling, traffic safety)

The Flow processes to which a moving vehicle is subjected fall into 3 categories:

1. Flow of air around the vehicle
2. Flow of air through the vehicle’s body
3. Flow processes within the vehicle’s machinery.

The aerodynamic drag D, as well as the other force components and moments, increases with the square of the vehicle speed V:

$$D \sim V^2$$

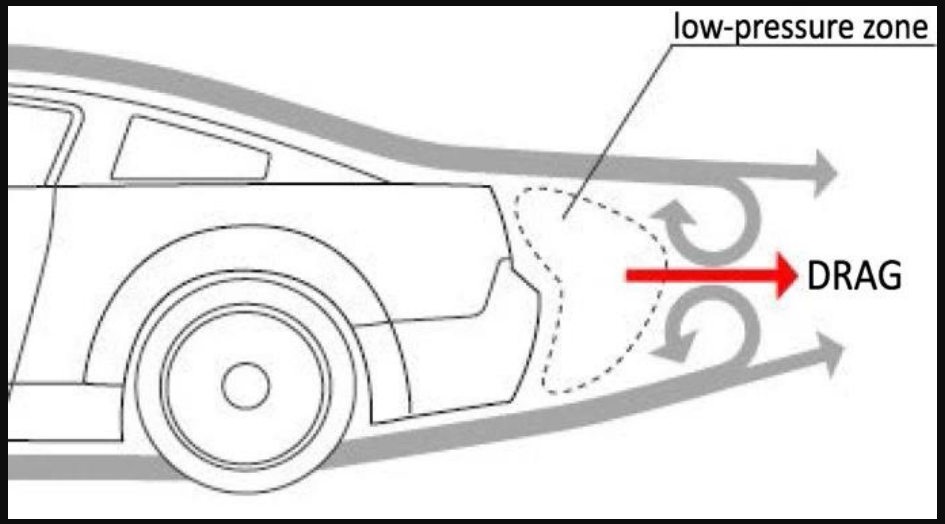
The scope for improving economy by reducing aerodynamic drag of the vehicle. For this reason, drag remains the focal point of vehicle aerodynamics, whether the objective is speed or fuel economy.

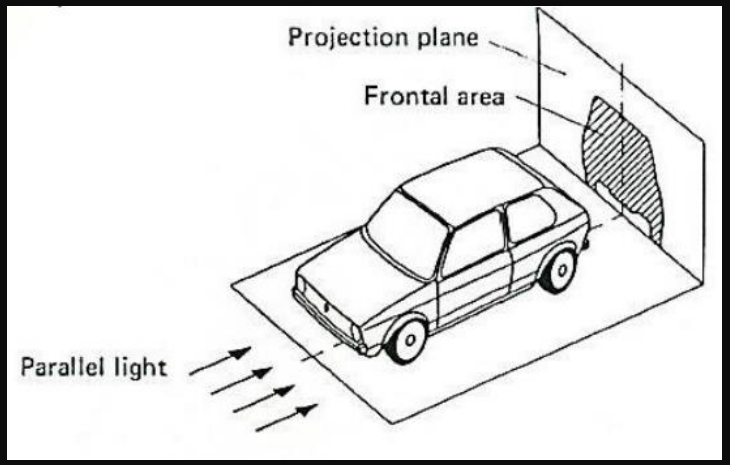
AERODYNAMIC DRAG

$$D = c_D A \frac{\rho}{2} V^2$$

Where,
c_D is the drag coefficient;
A is the projected frontal area of the vehicle
ρ is the density of the surrounding air.

The drag D of a vehicle is determined by its frontal area A, and by its shape, the aerodynamic quality of which is described by the drag coefficient c_D. Generally, the vehicle size, and frontal area, are determined by the design requirements, and efforts to reduce drag are concentrated on reducing the drag coefficient. The pressure difference between the upper and lower sides of the vehicle produces a resultant force, at right angles to the direction of motion, which is called lift. As a rule, the lift is in the upward direction, i.e. it tends to lift the vehicle and therefore reduces effective wheel loads. It is coupled with a pitching moment, which differentially affects the wheel loads at the front and rear.





SPECIFICATIONS

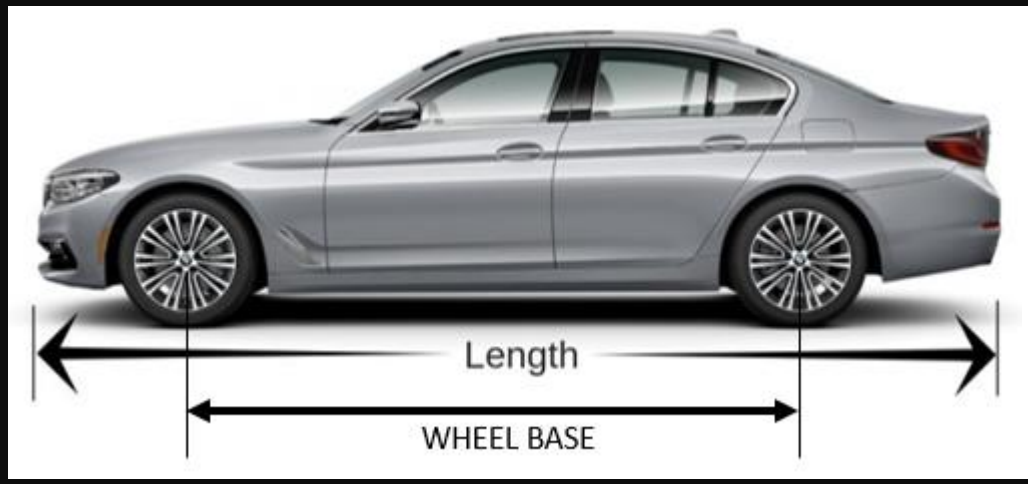
Based on Dimensional Attributes

Length

This is by far the easiest car spec sheet term to understand. Almost all of us will be able to straightaway decipher that this defines the length of the car from end to end. On the spec sheet, it is commonly denoted in millimeters. The length of the car majorly affects the handling and stability. As the length increases the straight line stability of the car goes up but the cornering agility decreases. Keep in mind, more length need not necessarily translate to leg room on the interior.

Width

Similar to the length, the width also simply denotes the dimensions of the car measured cross-sectionally. Unlike the length, more width does translate to more cabin room and more comfortable seating, especially for the rear passengers. Apart from that increasing the width also increases the straight line stability similar to the length. More width also means more frontal area which increases the level of air resistance thus decreasing the overall top speed. It is also denoted in millimeters and the spec sheet will usually specify if the mirrors are included in the measurement.



SPECIFICATIONS

Based on Dimensional Attributes

Height

The height of the car is defined as the height measured from its lowest point (i.e. the point where the tyres touch the road) to the tallest point on the car's roof. Leaving aside the headroom, the height of the car has a direct effect on the car's handling. A taller car will have a higher centre of gravity, lesser down-force and will experience more body-roll. Due to this, a taller car will feel very unsettled when pushed through corners. This is why all sports cars have low-slung body constructions which make them very agile through turns.

Wheelbase

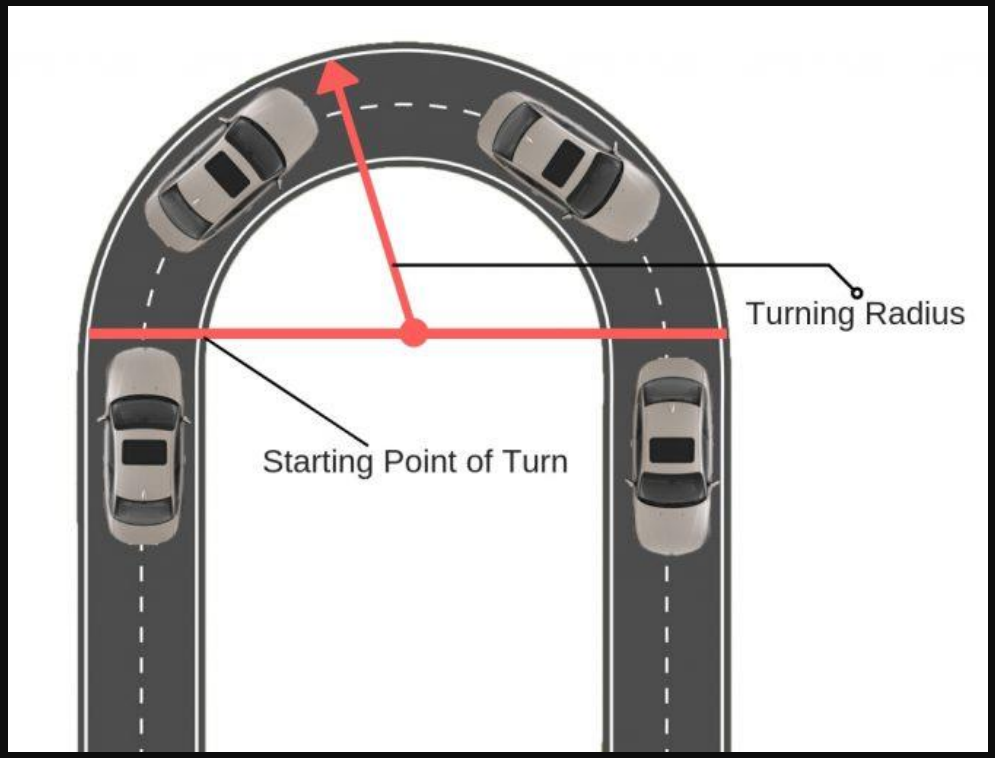
Now we commence with the more technical terms seen on the car spec sheet. The wheelbase is defined as the distance between the centres of the car's front wheel and rear wheel. Unlike the length, the wheelbase can be used as an indicator for interior room. A car with a longer wheelbase will feel more planted on straight roads but will move slower through the turns. Shorter wheelbase cars will have quicker handling but won't feel as firm-footed on the straights. The wheelbase influences these factors since it has a direct effect on turning radius which we will understand in the next point.

SPECIFICATIONS

Based on Dimensional Attributes

Turning Radius

The Turning radius of a car is a measure of its nimbleness and flick-ability. It is defined as the smallest diameter semi-circle that is required to be made by the car in order to make a complete U-Turn. Like we discussed in the previous point, the turning radius is primarily influenced by the car's wheelbase. The Turning radius is used to determine the maneuverability capabilities of the vehicle. Cars with a smaller turning radius will always be easier to navigate in tight traffic. Cars with a bigger turning radius, on the other hand, will feel more cumbersome in tight traffic as they will require more space to complete any maneuver



SPECIFICATIONS

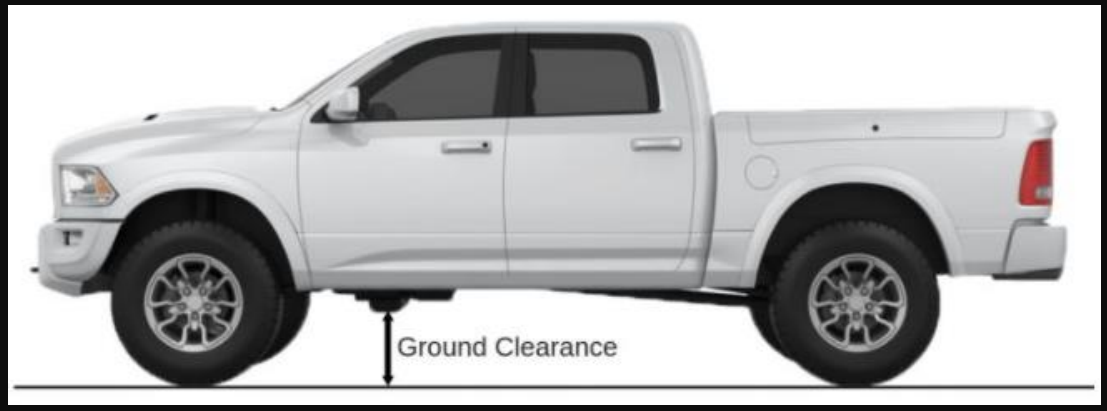
Based on Dimensional Attributes

Ground Clearance

The distance between the lowest point of the car body (excluding the wheels) and a levelled ground surface beneath it is defined as ground clearance. Ground clearance affects two major aspects, off-road capability, and handling. Naturally, when you have more room between the ground surface and your car under-body, you will be able to tackle bigger obstacles without them hitting the base of your car. Ground clearance affects handling the same way the height does. Decreasing the ground clearance reduces your car height and decreases the level of body roll, thus imparting the car with better and more stable handling.

Kerb Weight

Kerb weight is a very simple but often very confused term on the car spec sheet. If you notice any spec sheet or brochure for any car, you will notice the weight is never mentioned standalone, it is either in kerb weight or gross weight. Kerb weight is defined as the weight of the car without any passengers and luggage. It is counted with all the components in the car along with nominal levels of fuel and other fluids.



SPECIFICATIONS

Based on Engine Terminologies

Number of Cylinders

This refers to the number of combustion chambers present inside the engine. A majority of the cars in India are either 3-cylinder or 4-cylinder engines. 4 cylinder engines are smoother, have better performance and usually cost more. 3 cylinder engines are more fuel efficient, have lower running costs but aren't as refined as 4 cylinder engines. You can check out the differences in detail in our dedicated article

Number of Valves

The number of valves refers to the number of openings present on the top of each cylinder to induce air or remove exhaust gases. Nowadays almost all cars come with a 4 valve arrangement (2 for intake and 2 for exhaust). In the previous decade, 2 valve configurations were very popular but have been replaced almost entirely by their modern 4 valve counterparts. A few high-performance cars come with 5-valve (3 intake and 2 exhaust) engines as well.

Valvetrain Type

The Valvetrain refers to the orientation of the camshafts present inside the engine head. They are of two types, SOHC(Single Overhead Camshaft) and DOHC (Dual Overhead Camshafts). In the case of an SOHC valvetrain, a single camshaft is used to actuate both the intake and exhaust valves. This is achieved with the help of rocker arms linked to the valves on either side of the camshaft. A DOHC valvetrain contains two camshafts, one for the intake valves and one for the exhaust valves. In general, a DOHC arrangement is more superior to the SOHC arrangement. With a DOHC, the contact is directly between the cam and valves which increases precision, proper timing and performance as well. A properly tuned SOHC can perform as good as or better than a DOHC valvetrain but in base form, a DOHC arrangement is considered to be better.

SPECIFICATIONS

Based on Engine Terminologies

Displacement

In physical terms, the engine displacement simply refers to the total available volume in the engine cylinders. It is the summation of the individual air volume of each combustion chamber. It is measured in cubic centimeters or cubic capacity (cc) as we commonly know. The displacement has a very direct effect on the performance of your car. More displacement means more space for the engine to burn fuel which in turn gives more performance. Lesser displacement engines draw in a lesser quantity of fuel which means lesser performance but better fuel efficiency. Displacement is sometimes listed on the car spec sheet in terms of liters (1000cc = 1 litre).

Max Torque

Torque is defined as the total rotational force being exerted by the engine on the wheels of your car. Max torque refers to the maximum amount of torque that can be produced by the engine. This peak value is developed only at a certain RPM so it is usually mentioned as “X” Nm at “Y” RPM (eg- 233Nm at 3400RPM). The torque defines the pulling capacity and versatility of the engine’s powerband. More torque means the engine operates at lower RPM and has great pulling power regardless of the RPM you are in.

Hence you won’t have to perform frequent downshifts to stay in the correct powerband. The high torque present will allow the car to accelerate comfortably with its pulling power even if you are a gear or two higher. This is why diesel powered cars or SUVs are better suited for highway driving and long runs. Torque-packed cars generally prefer the lower end of the RPM range. Torque is measured in Nm or Newton-Metres.

SPECIFICATIONS

Based on Engine Terminologies

Max Power

Power is the sister function of torque. Power and torque the two primary parameters measuring engine performance on the car spec sheet. Technically speaking, power and torque are both derived from the same process. Power is equal to (Torque*RPM)/5252. Max power is again the maximum amount of power that the engine is capable of producing at a certain RPM. When we are talking power we are talking performance.

Engines designed to put out high levels of power are the ones which have high top speed, high acceleration and give that gut-wrenching sense of adrenaline. They might not be very good with the pulling capacity and could very well struggle with a lot of luggage or many occupants. But under normal conditions, a car with more power will always run faster. Such cars will feel at home in the upper end of the RPM range and not so much in the lower end. Power is measured in BHP or Brake Horse Power.

Drivetrain Type

The system that transfers power from the gearbox to the car axles is referred to as the drivetrain. There are 4 common types of drivetrains available in today's market namely, Front Wheel Drive (FWD), Rear Wheel Drive (RWD), All Wheel Drive (AWD) and 4-Wheel Drive (4WD). Here AWD and 4WD are the confusing terms since in both cases power is transferred to all 4 wheels. The difference here is that AWD is locked into this mode all the time. 4WD is more commonly offered on rugged SUVs and has to be toggled by the user. In case you find yourself in a stuck in mud or slush while off-roading, you can switch into the 4WD mode to help you get out of it.

SPECIFICATIONS

Based on Engine Terminologies

Transmission (Type and Speed)

Your car's transmission or gearbox as it is commonly known is one of the most important components in the engine. The gearbox is of two primary types, automatic and manual as most of you are probably familiar with. The Speed number of the gearbox denotes the number of gears available to shift into (e.g. a 4-Speed gearbox means the car has 4 gears). The only exceptional case here is the CVT type automatic transmission. A CVT has infinitely variable gears and no defined fixed gear ratio. This is the same type of transmission used on the majority of the automatic scooters as well.

PERFORMANCE PARAMETERS

Calorific Value (CV)

- The calorific value of a fuel is the thermal energy released per unit quantity of the fuel when the fuel is burned completely and the products of combustion are cooled back to the initial temperature of the combustible mixture.
- When the products of combustion are cooled to 25 ◦C practically all the water vapor resulting from the combustion process is condensed. The heating value so obtained is called the higher calorific value or gross calorific value of the fuel.

Indicated Thermal Efficiency (η_{ith})

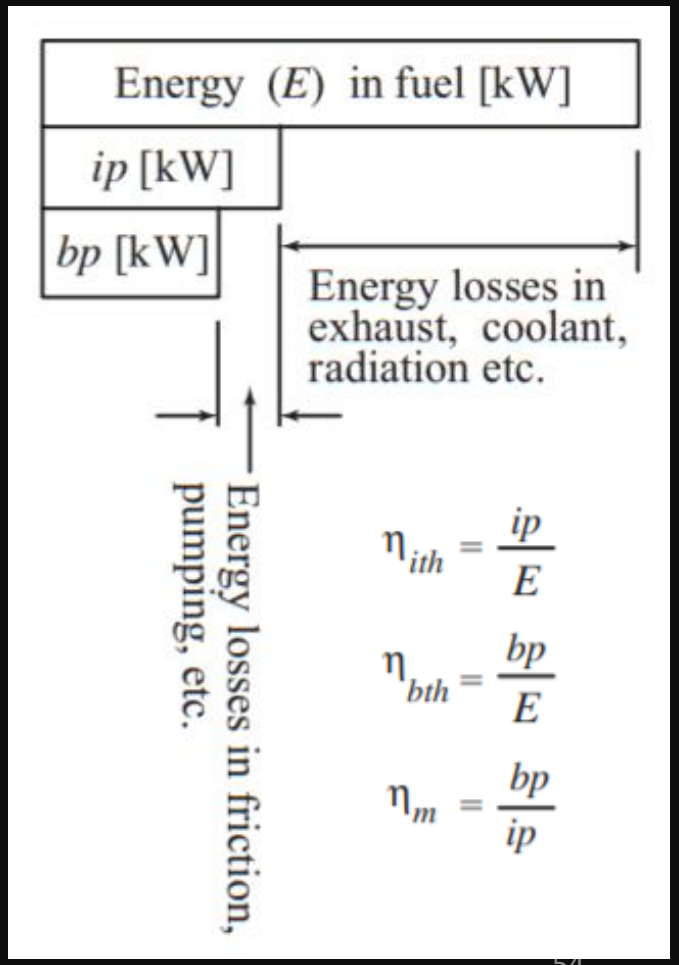
Indicated thermal efficiency is the ratio of energy in the indicated power, ip, to the input fuel energy in appropriate units.

$$\eta_{ith} = \frac{ip \text{ [kJ/s]}}{\text{energy in fuel per second [kJ/s]}}$$

Brake Thermal Efficiency (η_{bth})

Brake thermal efficiency is the ratio of energy in the brake power, bp, to the input fuel energy in appropriate units.

$$\eta_{bth} = \frac{bp}{\text{Mass of fuel/s} \times \text{ calorific value of fuel}}$$



PERFORMANCE PARAMETERS

Mechanical Efficiency (η_m)

Mechanical efficiency is defined as the ratio of brake power (delivered power) to the indicated power (power provided to the piston) or can be defined as the ratio of the brake thermal efficiency to the indicated thermal efficiency.

$$\eta_m = \frac{bp}{ip} = \frac{bp}{bp + fp}$$

$$fp = ip - bp$$

Relative Efficiency or Efficiency Ratio (η_{rel})

Relative efficiency or efficiency ratio is the ratio of thermal efficiency of an actual cycle to that of the ideal cycle. The efficiency ratio is a very useful criterion which indicates the degree of development of the engine.

$$\eta_{rel} = \frac{\text{Actual thermal efficiency}}{\text{Air-standard efficiency}}$$

Mean Piston Speed (sp)

An important parameter in engine applications is the mean piston speed, sp.

$$\overline{s}_p = 2LN$$

where L is the stroke and N is the rotational speed of the crankshaft in rpm. It may be noted that sp is often a more appropriate parameter than crank rotational speed for correlating engine behaviour as a function of speed.

PERFORMANCE PARAMETERS

Mean Effective Pressure (pm)

Mean effective pressure is the average pressure inside the cylinders of an internal combustion engine based on the calculated or measured power output. It increases as manifold pressure increases. For any particular engine, operating at a given speed and power output, there will be a specific indicated mean effective pressure, i_{mep}, and a corresponding brake mean effective pressure, b_{mep}

$$ip = \frac{p_{im} L A n K}{60 \times 1000}$$

then, the indicated mean effective pressure can be written as

$$p_{im} = \frac{60000 \times ip}{LAnK}$$

Similarly, the brake mean effective pressure is given by

$$p_{bm} = \frac{60000 \times bp}{LAnK}$$

where ip = indicated power (kW)
p_{im} = indicated mean effective pressure (N/m^2)
L = length of the stroke (m)
A = area of the piston (m^2)
N = speed in revolutions per minute (rpm)
n = Number of power strokes
$N/2$ for 4-stroke and N for 2-stroke engines
K = number of cylinders

Another way of specifying the indicated mean effective pressure p_{im} is from the knowledge of engine indicator diagram (p-V diagram). In this case, p_{im}, may be defined as

$$p_{im} = \frac{\text{Area of the indicator diagram}}{\text{Length of the indicator diagram}}$$

where the length of the indicator diagram is given by the difference between the total volume and the clearance volume.

Maruti 800

Max Power (bhp @ rpm) - 37bhp@5000rpm
No. of cylinder - 3
Bore X Stroke - 68.5 x 72.0 mm

Mahindra Thar

Max Power (bhp @ rpm) - 130bhp@3750rpm
No. of cylinder - 4
Bore X Stroke – 80 x 96.0 mm

PERFORMANCE PARAMETERS

Mean Piston Speed

An important parameter in engine applications is the mean piston speed, sp.
It is defined as

$$\overline{s}_p = 2LN$$

where L is the stroke and N is the rotational speed of the crankshaft in rpm.
It may be noted that s_p is often a more appropriate parameter than crank rotational speed for correlating engine behavior as a function of speed.
Resistance to gas flow into the engine or stresses due to the inertia of the moving parts limit the maximum value of s_p to within 8 to 15 m/s. Automobile engines operate at the higher end and large marine diesel engines at the lower end of this range of piston speeds.

Specific Power Output (Ps)

The specific power output of an engine is defined as the power output per unit piston area and is a measure of the engine designer's success in using the available piston area regardless of cylinder size.
The specific power can be shown to be proportional to the product of the mean effective pressure and mean piston speed. Specific power output

$$\begin{aligned} \text{Specific power output, } P_s &= bp/A \\ &= \text{constant} \times p_{bm} \times \overline{s}_p \end{aligned}$$

Specific Fuel Consumption (s_{fc})

The fuel consumption characteristics of an engine are generally expressed in terms of specific fuel consumption in kilograms of fuel per kilowatt-hour. It is an important parameter that reflects how good the engine performance is. It is inversely proportional to the thermal efficiency of the engine.

$$\text{sfc} = \frac{\text{Fuel consumption per unit time}}{\text{Power}}$$

Brake specific fuel consumption and indicated specific fuel consumption, abbreviated as bsfc and isfc, are the specific fuel consumptions on the basis of bp and ip respectively.

Air/fuel Ratio and Fuel/Air Ratio

The relative proportions of the fuel and air in the engine are very important from the standpoint of combustion and the efficiency of the engine. This is expressed either as a ratio of the mass of the fuel to that of the air or vice versa. In the SI engine, the fuel-air ratio practically remains constant over a wide range of operations. In CI engines at a given speed, the airflow does not vary with load; it is the fuel flow that varies directly with the load. Therefore, the term fuel-air ratio is generally used instead of air-fuel ratio.

- A mixture that contains just enough air for complete combustion of all the fuel in the mixture is called a chemically correct or stoichiometric fuel-air ratio.
- A mixture having more fuel than that in a chemically correct mixture is termed a rich mixture
- A mixture that contains less fuel (or excess air) is called a lean mixture.

For most hydrocarbon fuels, the stoichiometric air-fuel ratio is around 15:1. SI engines operate around this ratio during normal operation. The air-fuel ratio for CI engines varies from 18:1 to 80:1 from full load to no load.

The ratio of actual fuel-air ratio to stoichiometric fuel-air ratio is called equivalence ratio and is denoted by φ.

$$\phi = \frac{\text{Actual fuel-air ratio}}{\text{Stoichiometric fuel-air ratio}}$$

Bharat New Vehicle Safety Assessment Program (BNVSAP)

- The Bharat New Vehicle Safety Assessment Program (BNVSAP) is a proposed New Car Assessment Program for India
- Under this Programme, Cars sold in the country will be assigned by star ratings based on their safety performance.
- It will be implemented in phases, according to the plans being drawn up by the National Automotive Testing and R&D Infrastructure Project.
- New cars sold in India will need to comply with voluntary star ratings based on crash safety performance tests. Critical safety features such as airbags, ABS and seat belts will become standard in cars sold in India resulting from rankings and mandatory crash testing.
- It is mandatory for a car to clear car crash safety tests such as Offset front crash, side crash, and rear crash impact tests required by 2017.
- Cars will gradually have to meet more stringent norms such as pedestrian protection, whiplash injury and child restraint systems standards and requirements.
- The proposed speed for offset frontal crash testing vehicles under Bharat National Car Assessment Programme is 56kph which is lower than Global NCAP's proposal of 64kph.