

AT8801

VEHICLE BODY ENGINEERING

L T P C
3 0 0 3

OBJECTIVE:

- The main objective of this course is to impart knowledge in the construction of vehicle, aerodynamic, concept, paneling of passenger car body trim. At the end of the course the student will be well versed in the design and construction of external body of the vehicles.

UNIT I CAR BODY DETAILS

10

Types of Car body - Saloon, convertibles, Limousine, Estate Van, Racing and Sports car – Visibility-regulations, driver's visibility, improvement in visibility and tests for visibility. Driver seat design -Car body construction-Variou panels in car bodies. Safety aspect of car body.

UNIT II BUS BODY DETAILS

9

Types of bus body: based on capacity, distance traveled and based on construction.– Bus body lay out for various types, Types of metal sections used – Regulations – Constructional details: Conventional and integral. driver seat design- Safety aspect of bus body.

UNIT III COMMERCIAL VEHICLE DETAILS

8

Types of commercial vehicle bodies - Light commercial vehicle body. Construction details of commercial vehicle body - Flat platform body, Trailer, Tipper body and Tanker body – Dimensions of driver's seat in relation to controls – Drivers cab design - Regulations.

UNIT IV VEHICLE AERODYNAMICS

9

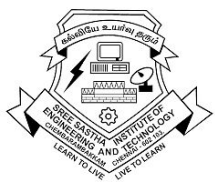
Objectives, Vehicle drag and types. Various types of forces and moments. Effects of forces and moments. Side wind effects on forces and moments. Various body optimization techniques for minimum drag. Wind tunnels – Principle of operation, Types. Wind tunnel testing such as: Flow visualization techniques, Airflow management test – measurement of various forces and moments by using wind tunnel.

UNIT V BODY MATERIALS, TRIM, MECHANISMS AND BODY REPAIR

9

Types of materials used in body construction-Steel sheet, timber, plastics, GRP, properties of materials. Body trim items-body mechanisms.Hand tools-power tools-panel repair-repairing sheet metal-repairing plastics-body fillers-passenger compartment service- corrosion: Anticorrosion methods, Modern painting process procedure-paint problems

TOTAL : 45 PERIODS



OUTCOMES

Upon completion of the course, students will

- Know about different aspects of car body and bus body, types, commercial vehicle.
- Role of various aerodynamic forces and moments, measuring instruments
- Know about the material used in body building, tools used, body repairs.

TEXT BOOKS:

1. James E Duffy, "Body Repair Technology for 4-Wheelers", Cengage Learning, 2009.
2. Powloski, J., "Vehicle Body Engineering", Business Books Ltd., 1998.

REFERENCES:

1. Braithwaite, J.B., "Vehicle Body building and drawing", Heinemann Educational Books Ltd., London, 1997.
2. Dieler Anselm., The passenger car body, SAE International, 2000
3. Giles, G.J., "Body construction and design", Illiffe Books Butterworth & Co., 1991.
4. John Fenton, "Vehicle Body layout and analysis", Mechanical Engg. Publication Ltd., London, 1992.

The first Volvo SUV?



1943



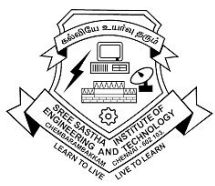
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History of the Development of Vehicle Body Engineering

•Aerodynamic Drag, Aesthetic Look , Less Vehicle Weight and other factors compelled Vehicle Designers to pay more attention on the body design.

•Henry Ford – Produced First Car Body – 'MODEL T' in 1913 with a slogan 'a car for every one'

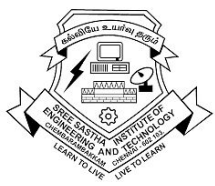
•Ford Next Model - Model A – Ford Eliminated many of the Wooden components



- In 1920 – **Budd Corporation in Philadelphia** - took out a patent for all metal body car with welding

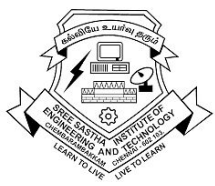
- In 1930 – Joining of Sheet Metal Components was greatly simplified by the introduction of **electric resistance welding (Spot Welding)** – Mass Production of Vehicles

- In 1950 – Unibody Construction – Body becomes the load bearing structure



Importance of Vehicle Body Design

- Total Weight (TW) of the Vehicle – Large Extent Determined by Structural Weight
- Private Cars – Body Contributes 40 -60 Percentage of TW
- Buses – Body Contributes 60 -70 Percentage of TW
- Pay Load – Body Weight, GVW (Tyre & Components) is const for most of vehicles
- Reduction in Body Weight improves vehicle capacity, Fuel Consumption & many other factors.
- Aerodynamic Characteristic – determine the fuel consumption at high speed & stability in cross winds

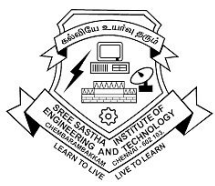


Customer Expectation in Vehicle Body Design

- Well Designed Seats
- Dashboard Layout
- HVAC
- Easy Entry & Exit
- Styling of the Vehicle
- Attractive Appearance of a given car can be equated with the rate of growth of the Vehicle Industry.
- Crash Safety or Roll Over Safety
- Vehicle Body determines the Vehicle Price (Direct & Indirect)

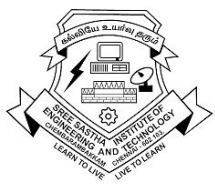
Customer Expectation in Vehicle Body Design

- In Direct Price the body represents between 50 & 70 percent of the total cost of the vehicle
- In indirect Cost the expected life of the vehicle can also influence the price



Requirements of Automobile Body

- Frt & Rear Bumpers : Reasonable Impact Loads
- Floor Panels – Swages , Reduce the Vibration
- Instrument Panel – controls, Lights, Meters,- Operated with least effort
- Wheel Arch Panel – Enough Clearance for up & down movement of Wheels
- Bonnet – Hinged near Wind screen & has a prop to keep it open



Requirements of Automobile Body

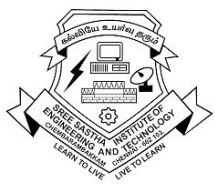
- Strength: Withstand all Forces
- Bending Stiffness- Prevent Sagging
- Torsional Stiffness - Rigid
- Air Drag- Body Shape
- Weather Protection- Occupants & Luggage
- Corrosion Resistance- Body Materials
- Accident Protection- Body design ease to driver
- Adequate Space

Advantages of Unibody construction :

- Less weight, Less Fuel Consumption
- Reduces Manufacturing Cost
- Body crumples, thereby absorbing the shock due to impact
- C.G Lower

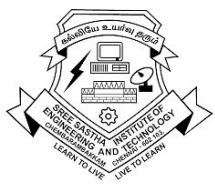
Disadvantages of Unibody construction :

- Increased Cost of Repair
- Reduction in strength & Durability
- Suitable for Mass Production
- Difficult to eliminate body noise
- Steel on Underside - Corrosion



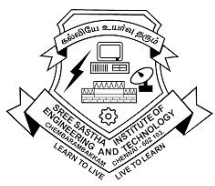
Types of Automobiles:

1. Use: Van, Truck, Articulated Vehicle ,Bus, Coach
2. Capacity: HTV,LTV
3. Make & Model: GM 'SPARK'
4. Fuel Used: Petrol, Diesel
5. Body Style: Saloon, Hatchback etc
6. Wheels: wire spoked wheels, alloy wheels
7. Drive: FMRD,RMRD,FMFD
8. Transmission: Manual,Automatic



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UNIT I CAR BODY DETAILS

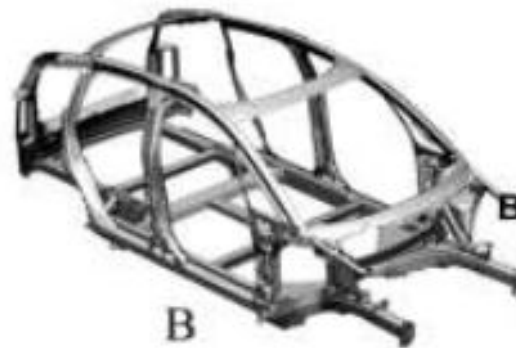
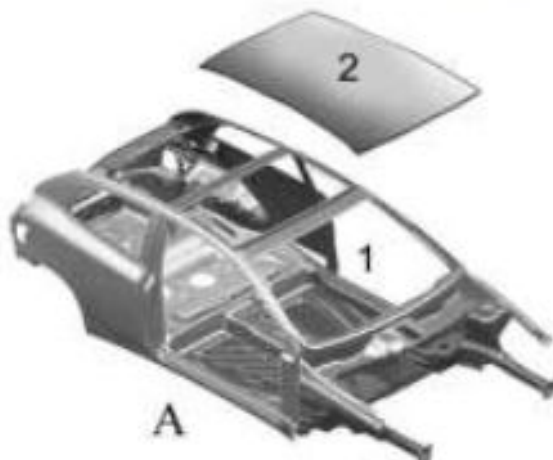
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1.0.4. CAR BODY DETAILS - BODY IN WHITE

All vehicle manufacturers aim to build the perfect body in white (BIW). It is the basis of a premium quality, light-weight car.

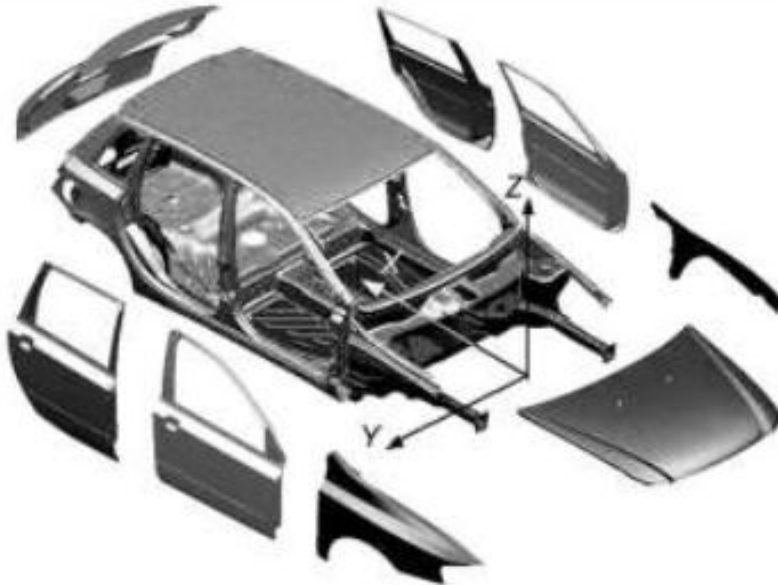
- × In the usual configuration, a body in white is an assembly of a frame and **panels**, made up of **homogeneous materials** (for instance, **steel** or **aluminum sheets** or **composites**).
- × As an example, in Fig. a 3-door steel body and the frame of a 5-door aluminum body are shown.



A) Body in white steel sheets (1) and roof panel (2) of Fiat Stilo 3-doors, before their assembly.

B) Audi A2 aluminum body frame. (5-door)

1.0.4. CAR BODY DETAILS - BODY WORK

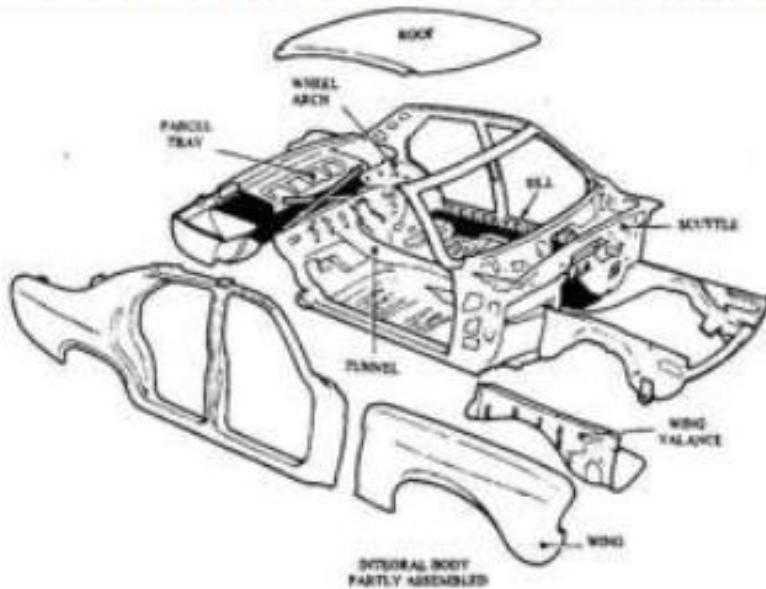


Body in white with movable parts and three dimensional reference system

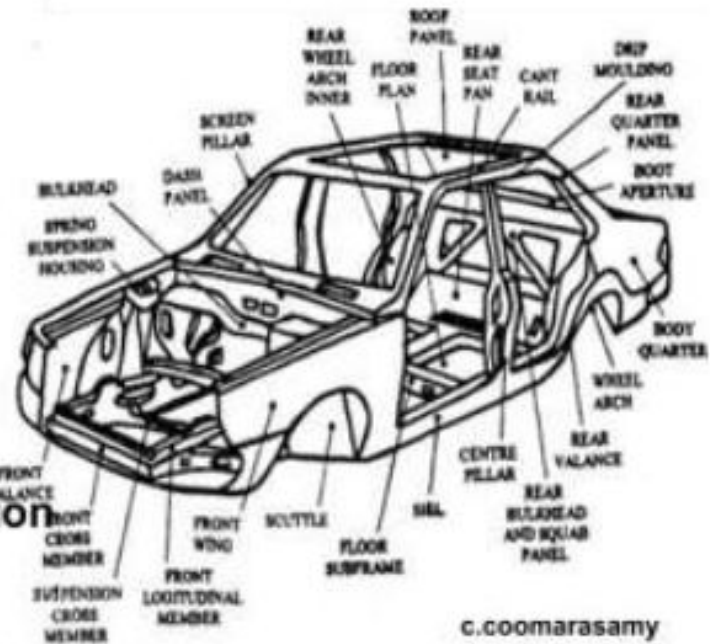
Many detachable components are fitted to the body, such as the so-called

- × **movable parts** (eg. doors, deck lid, lift gate, hood, fuel filler flap and related locks and hinges),
- × **external components** (bumpers, windshield, windows, weather strips, grilles, spoilers, moldings, mirrors, lamps, windshield wipers, lamp wipers) and
- × **interior trim** (instrument panel, seats, carpets, trim panels, safety belts, air bags), together constituting the **vehicle body**.

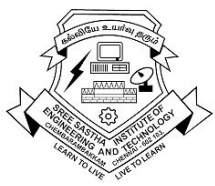
1.1.0. TYPES OF CAR BODIES



Integral body construction

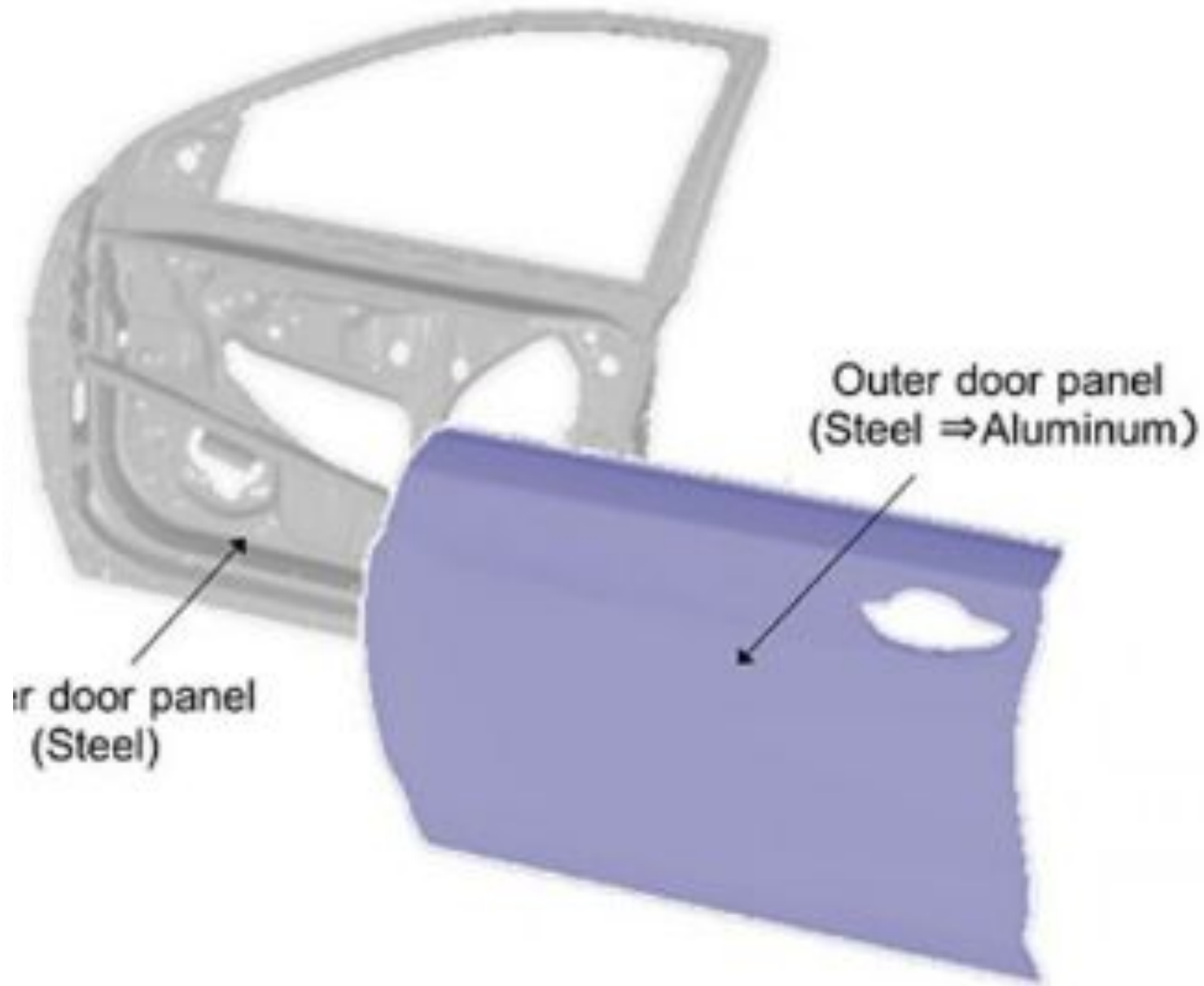


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Constructional Details of Car Body

- Car Body : Many Sheet Metal Panels are Spot Welded Together
- Basic Structure has Two Panels – Outside & Inside Panels
- Outside Panels – Contour or Shape of Car Body
- Curved Shapes in Panel – to Incorporate Strength
- Reinforcement – Inner Panels
- Outer & Inner Panels are welded together & to pillars & rails form the Skelton of carbody
- Body Sill & Pillars are the main load taking members

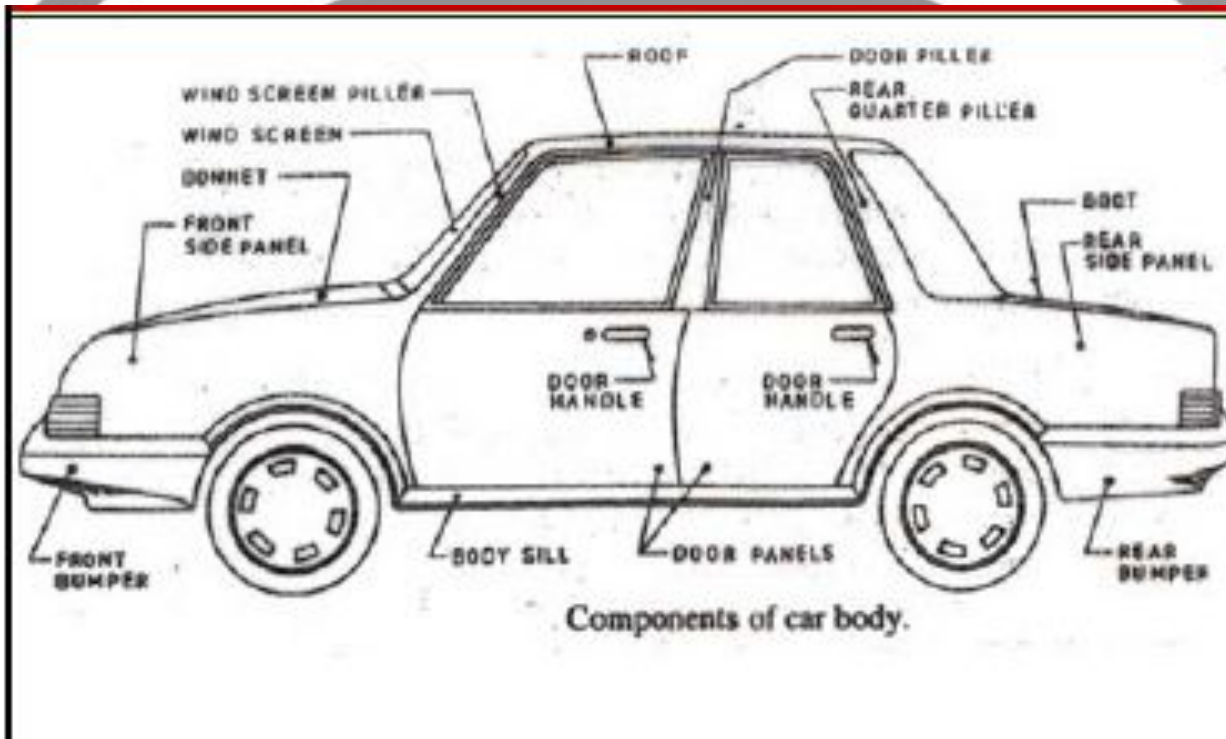


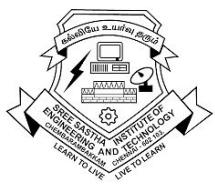


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THE AUTOMOTIVE MANUAL



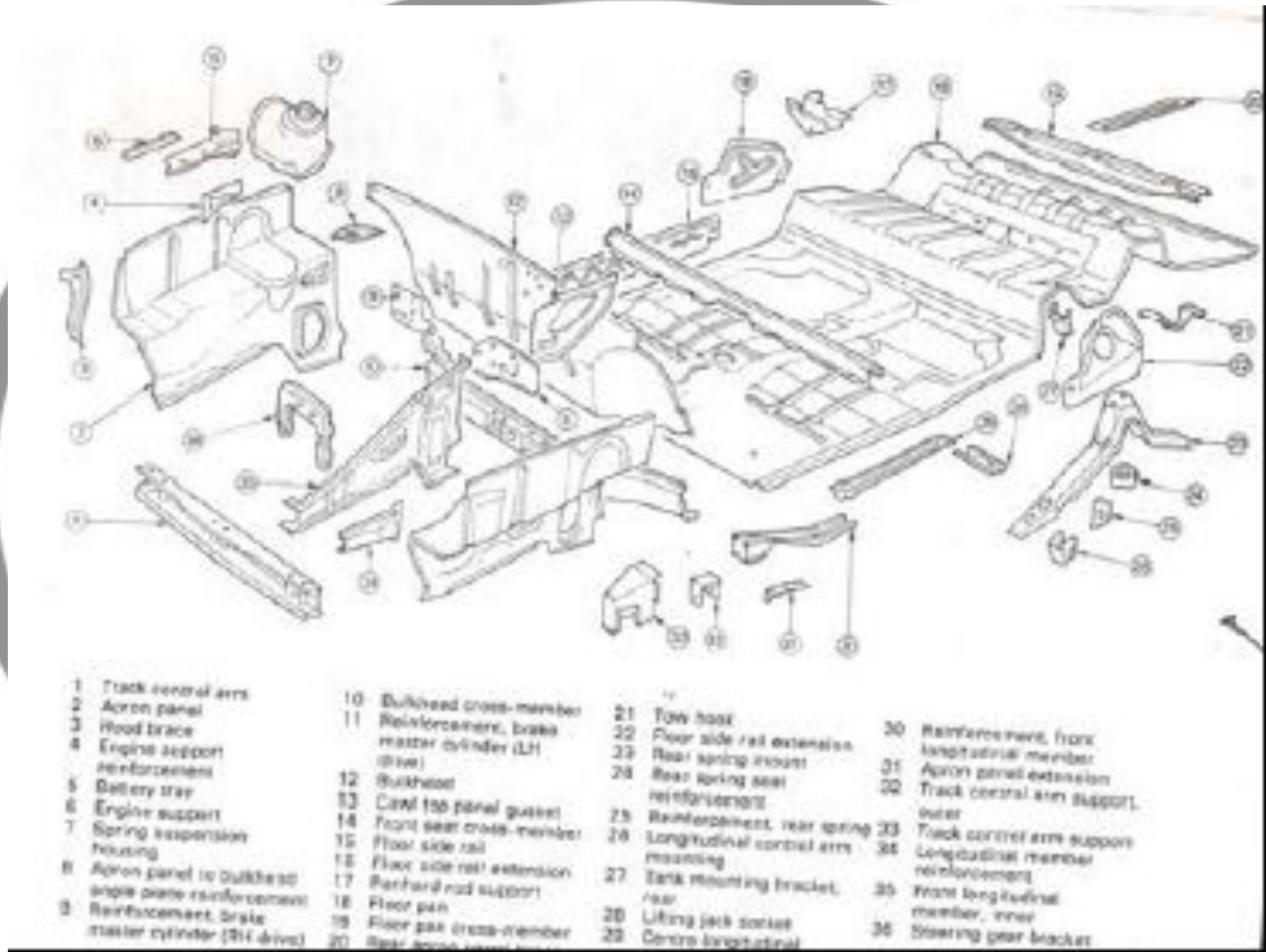




Constructional Details of Car Body

- Windscreen – Safety Glass – Large Enough – Good Vision to Driver - Curved for Streamlining
- Door Panels & Side Panels – Strong – side impact
- Firewall – Insulated Sheet Metal Panel – Separates the front passenger space from the engine space





CAR BODY TERMINOLOGY

Cant Panel – Curved section of the roof top running b/w the comparatively flat top & the rain channel or gutter

Cant Rail – Longitudinal framing of the roof at the joint

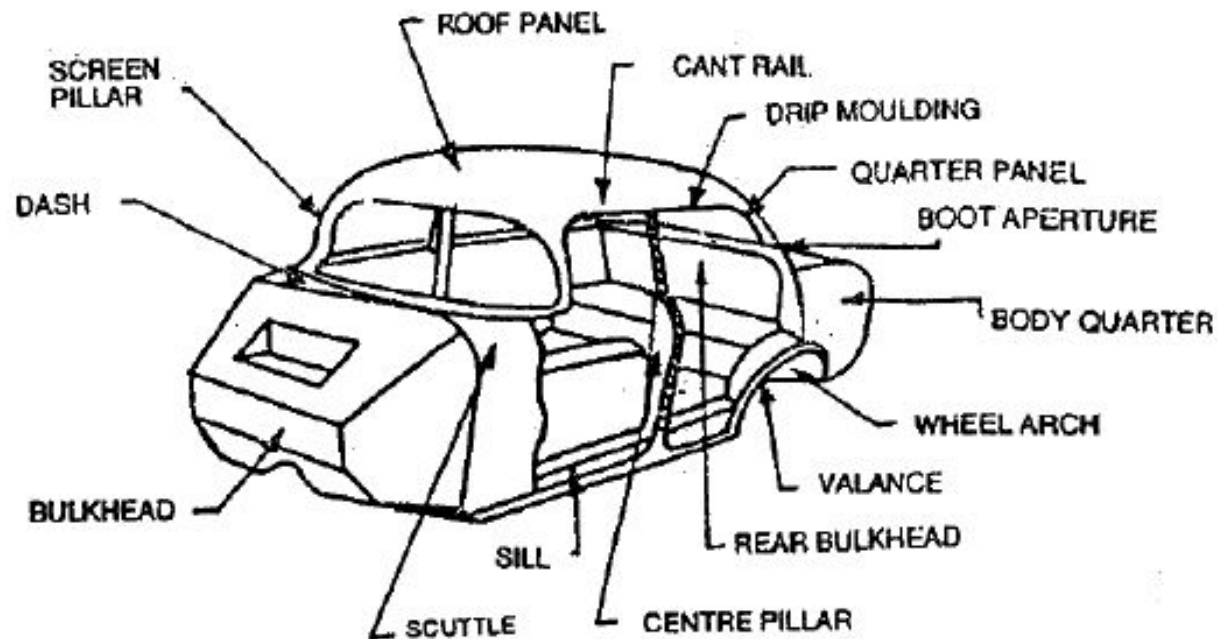
Centre Pillar – Centre vertical support of a four door saloon, B-C post - Shut Face for Frt door with lock striking plate & hinge pillar for rear door.

Toe Board – Foot Pedals

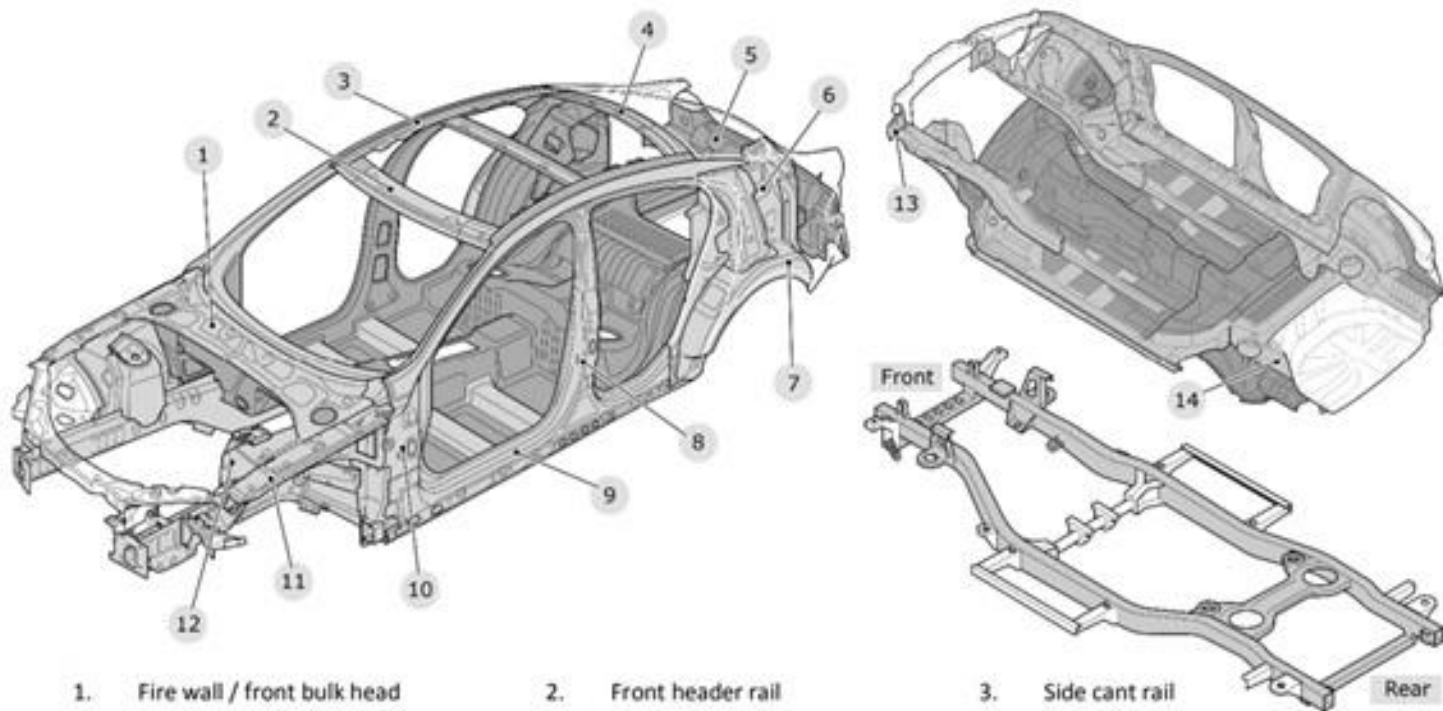
Door Skins – Door Exterior Panels

Door Trim – Door Interior Lining panel

Body work and Integral Construction:



A car body.



1. Fire wall / front bulk head

4. Rear header rail

7. Rear wheel housing extension

10. A post

13. Front chassis leg /welded cross member

2. Front header rail

5. Rear cross member *

8. B post

11. Front upper wing support

14. Rear chassis leg

3. Side cant rail

6. Rear inner wing

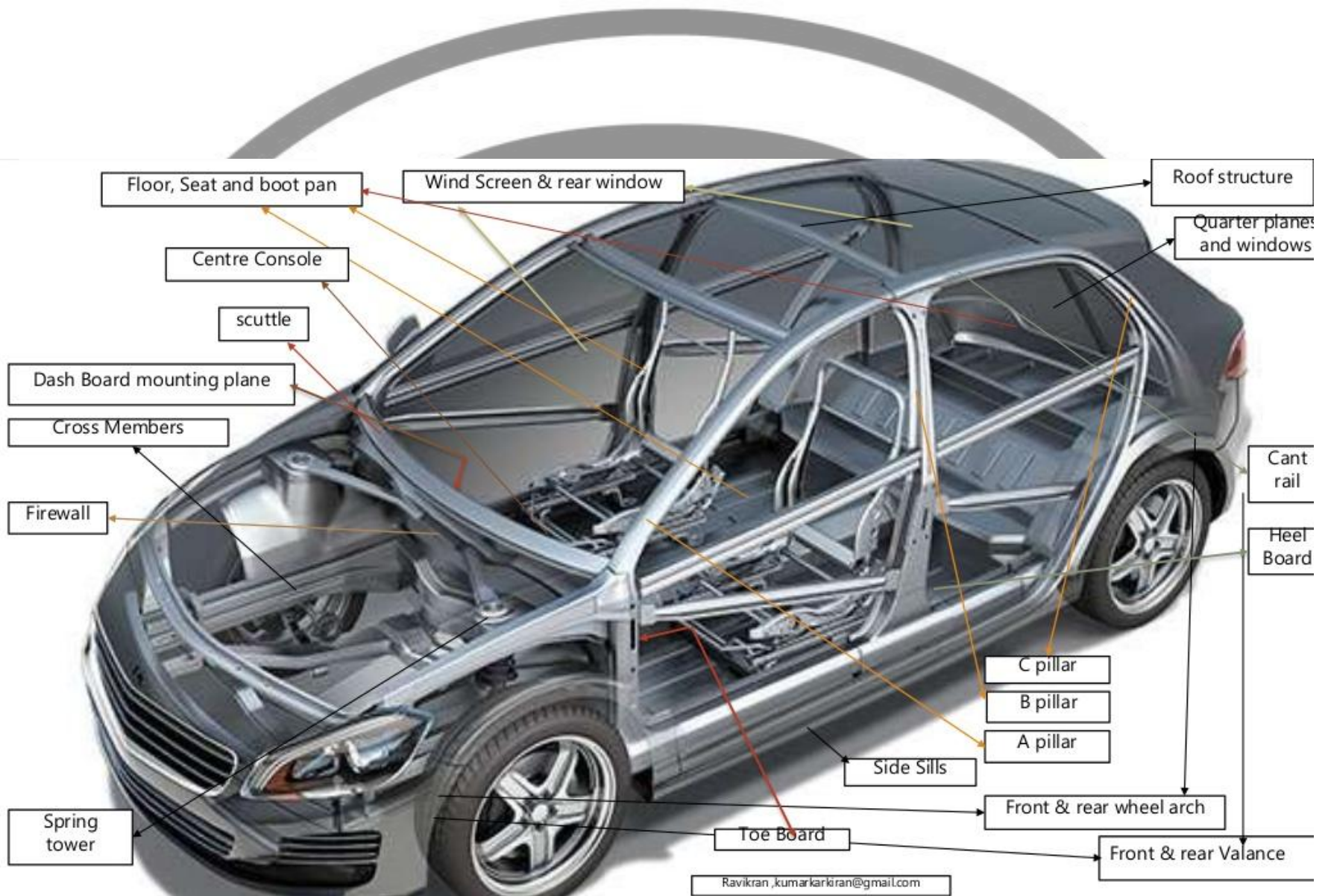
9. Sill

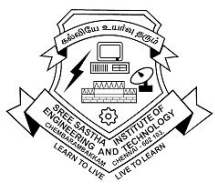
12. Front Inner wing



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CAR BODY TERMINOLOGY

Drip Moulding – Roof Gutter to direct water from door openings

Fender – American term for wing

Firewall – Dividing Engine & passenger compartment

Flange – A reinforcement on the edge of the panel formed at approximately right angles to the panel

Heel Board – Vertical Board or Panel under rear seat which forms the support for the seat cushion

Hood – American Term for bonnet

CAR BODY TERMINOLOGY

Scuttle Panel - Panel b/w the bonnet & windscreen

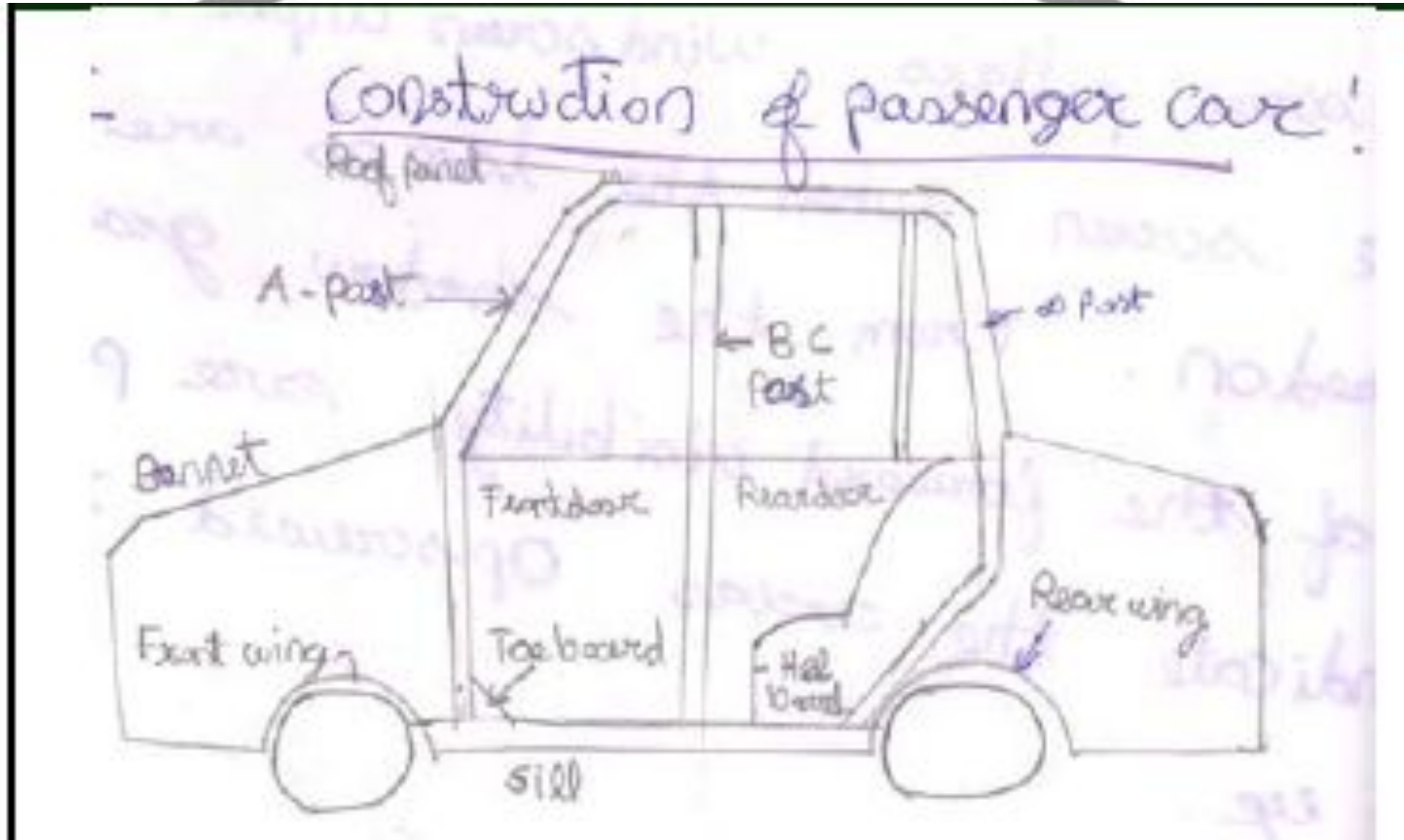
Squab - Rear Seat Back Construction

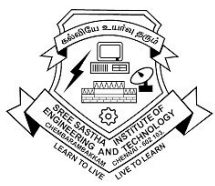
Sub frame - Members to which the Engine & Frt Assembly are attached

Tunnel - A raised floor panel section for drive shaft clearance

Turret - American term for roof

Wheel Arch - Panel forming the inner housings for the road wheels





Constructional details

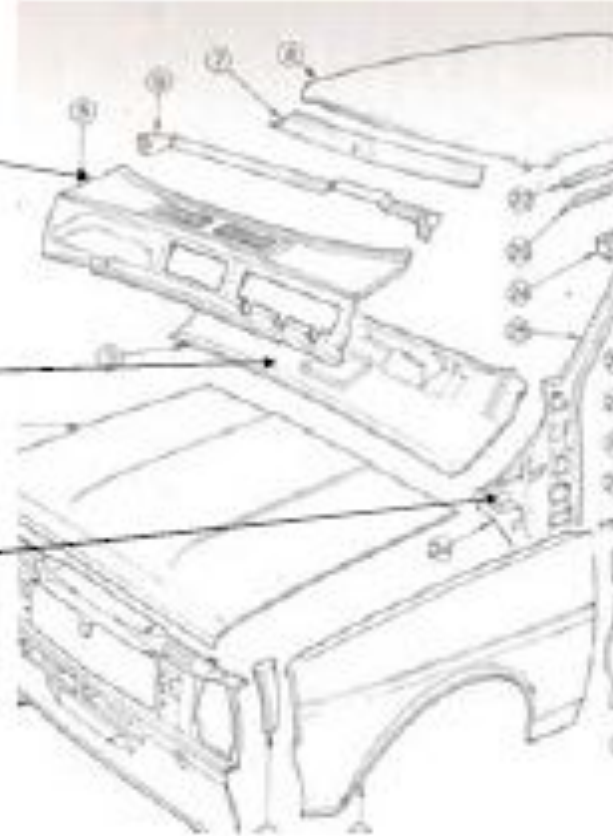
- Roof,
- Under Floor,
- Bonnet,
- Boot,
- Wings

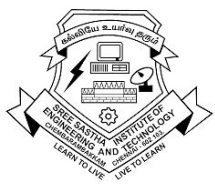
Cowl Panel or Dash Panel

Cowl Top Panel
Reinforcement

Cowl Top Panel

Top Cowl Side Panel





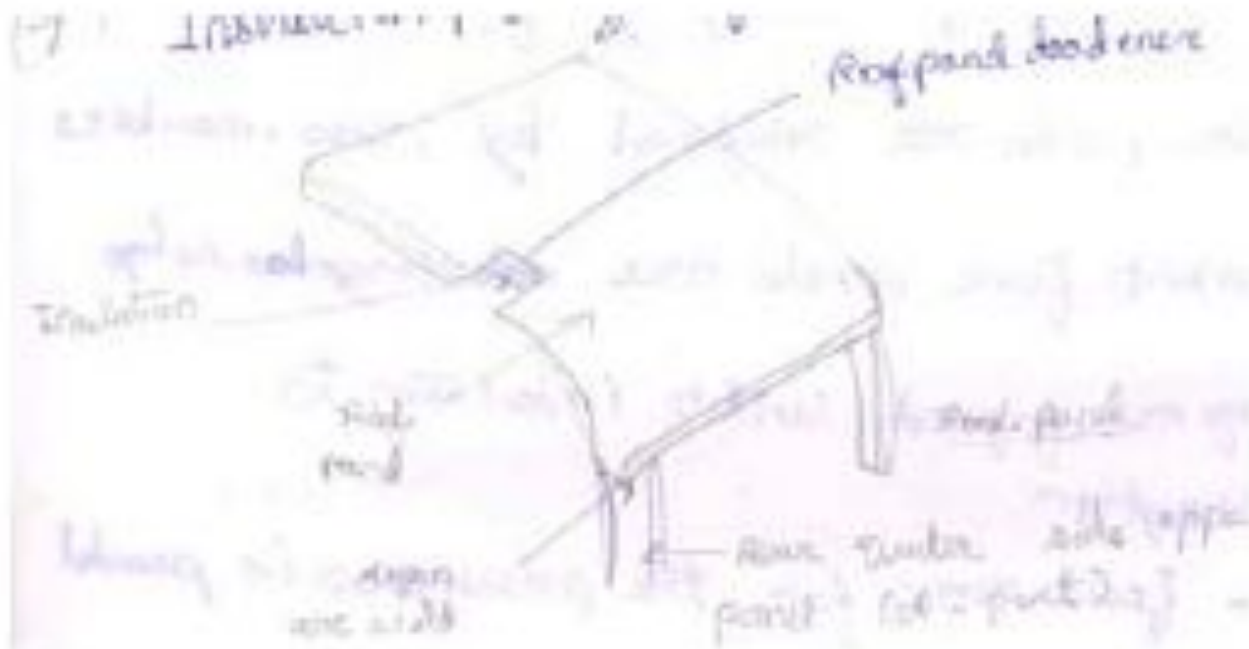
Major Body Panels/ Pressings

Cowl Panel or Dash Panel

- Frt Bulk Head – Assembly of Several Smaller Panels
- Cowl Upper Panel & Side Panel
- Some Cases – Windscreen Opening is a part of Cowl Panel –ie Cowl Panel extends Upward
- Top Edge of Cowl Coincides with Front Edge of roof panel
- Firewall – Opening for Controls & Wiring
- Instrument Panel (IP) – part of Cowl Panel
- Complex

Major Body Panels/ Pressings

ROOF Panel



Major Body Panels / Fittings

ROOF Panel

8 – Roof

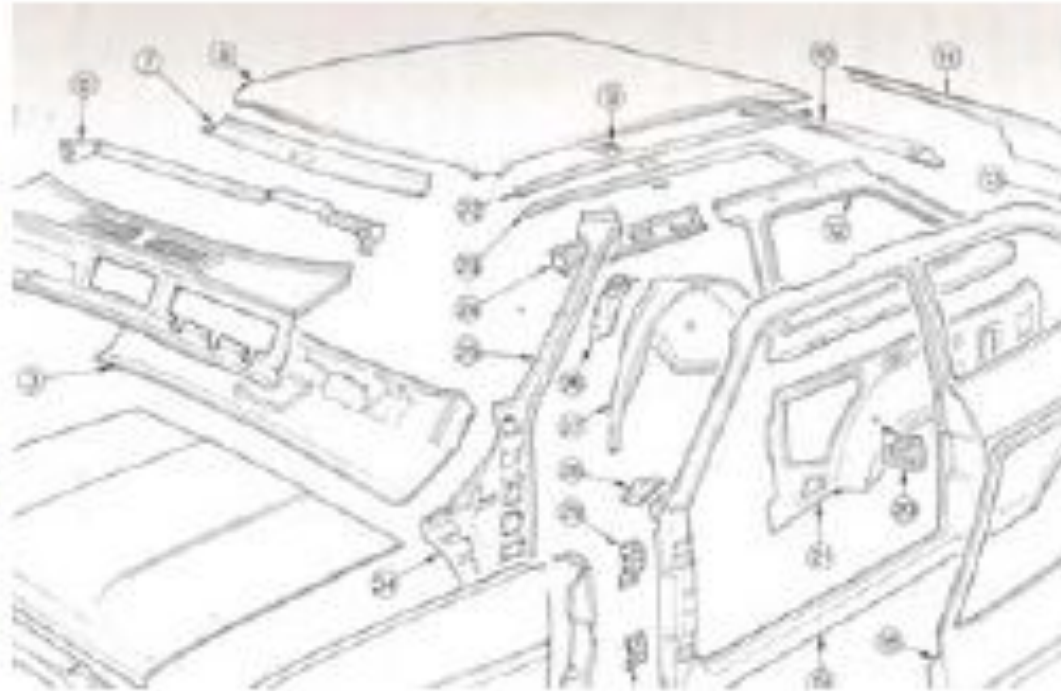
7- Roof Rail

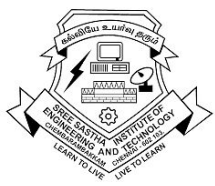
9 – Roof Support

10 – Top Rear
panel Frame

22, 23 – Roof Drip
Rail

24 – Roof Frame
reinforcement





Major Body Panels/ Pressings

ROOF Panel

- **Largest** of all Major Body Panels
- Simple in Construction – **All steel one Piece Construction**
- Area of Roof Cover Varies b/w Makers & Model of Cars
- Roof Panel ends at the foot /top of Windscreen or Exterior
Downwards – **Frt or Rear**
- **Windscreen (Frt & Rear is a part of roof)**
- Roof Panels are provided with **metal straps** for securing
headlining & inside trim is provided
- **Insulation Package** for Luxury Car

Major Body Panels/ Pressings

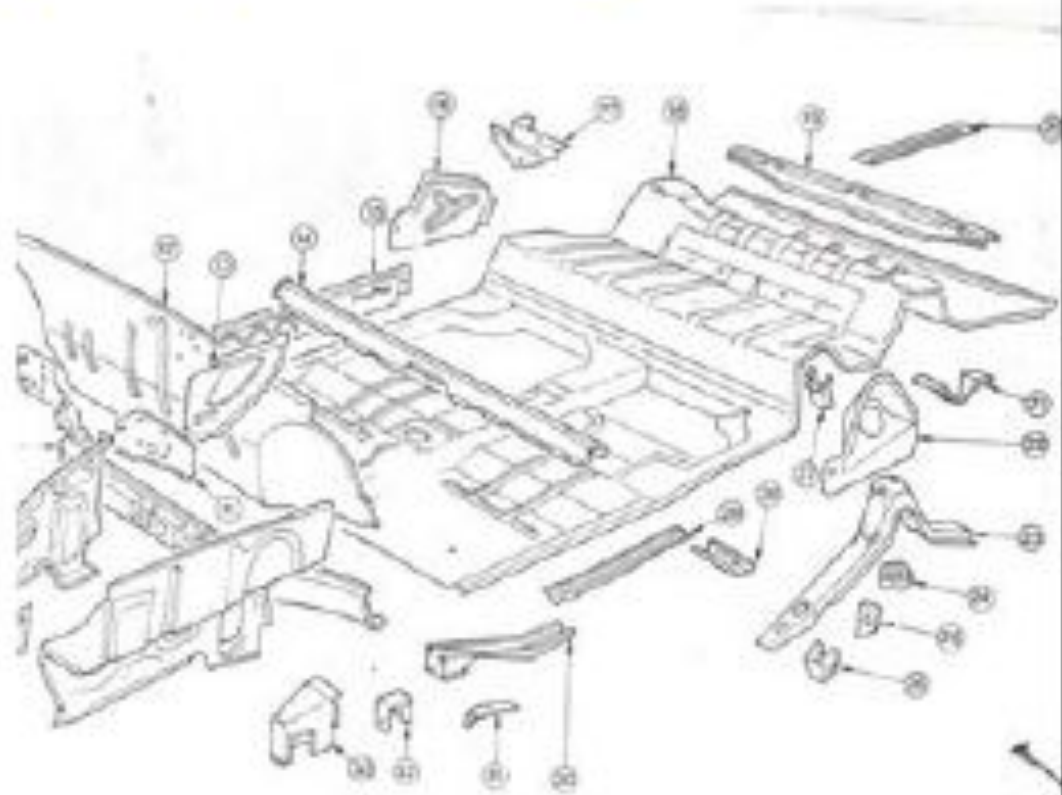
UnderBody

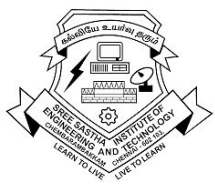
18 – Floor Pan

19 – Floor pan
Cross Member

15 – Floor Side
Rail

16 - Floor Side
Rail Extension

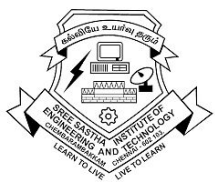




Major Body Panels/ Pressings

UnderBody

- Floor Panel – Composed of Smaller Panels to form a **Single Floor Unit**.
- Floor panels are reinforced by Cross- Members
- Most Floor Panels are irregular in Shape
- Passenger Compartment is Strengthened



Major Body Panels/ Pressings

Rear Quarter Panel

- Integral With Rear Wing – inner & Outer Construction
- Outer panel is turned over the inner panel at the edge
- Welding/Bolts - Outer panel & inner panel
- Inner Construction is made up of many strong reinforcement brackets to form a single unit
- Extends across the Vehicle at the rear of passenger compartment supports rear seat back

Major Body Panels/ Pressings

Centre Pillar (B.C Post)

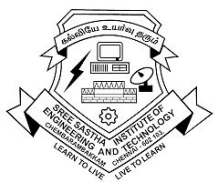
- Act as Central & Side Support b/w front & rear of car
- Strong Enough acts as a hinge pillar to rear door & lock pillar to front door
- Pillar is wide – Outer panel surface is visible from outside when the door is closed
- Provisions for Door Lock, Striker Plate & Hinges



Major Body Panels/ Pressings

Centre Pillar (B.C Post)





Major Body Panels/ Pressings

Rear Wheel Arch Assembly

- Integral part of inner construction of rear quarter panel
- Two Piece construction ie **Wheel Arch & Quarter Panel**

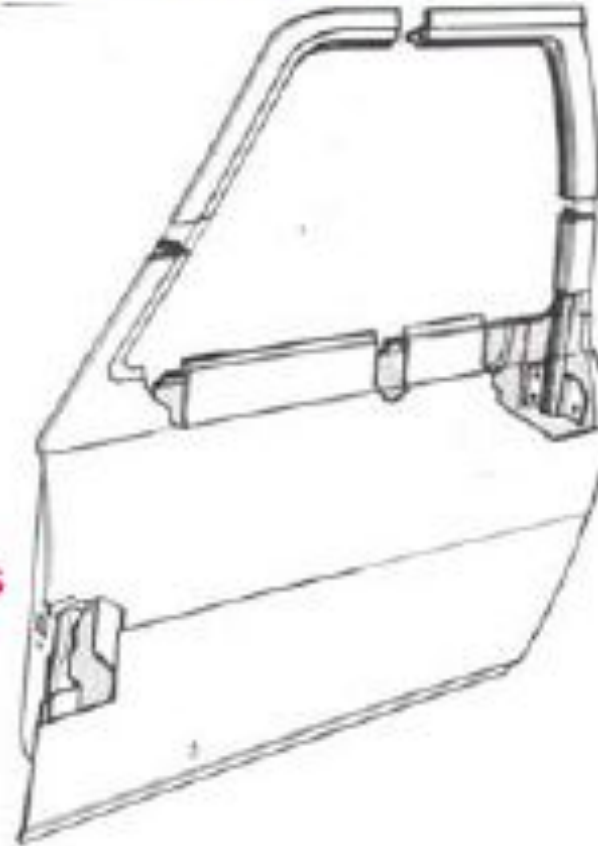
Door

- Outer Panel & Inner Panel
- Steel - Inner Panel provides **strength – frame for door**
- Outer Panel Flanges over the inner edge of Inner panel
- Inner Panel – **holes for attaching door trim stems**

Major Body Panels/ Pressings

Doors

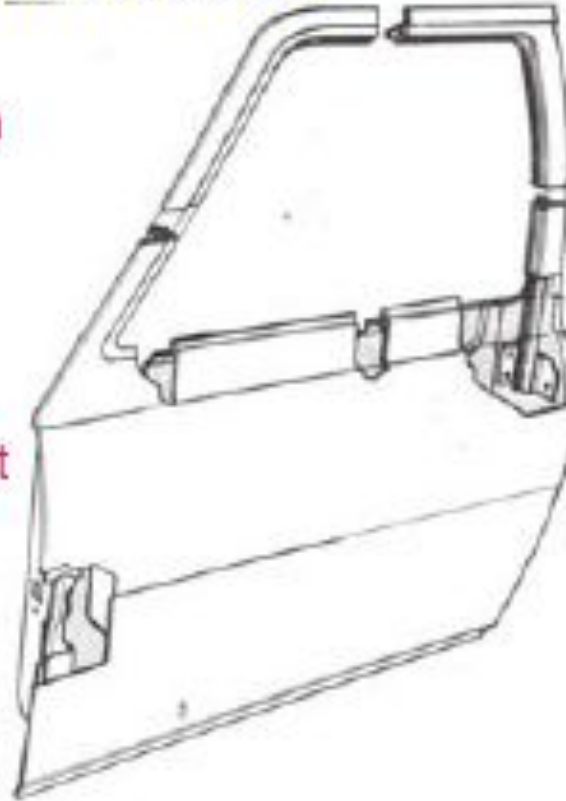
- Trim window regulator Assembly & door lock mechanism
- Door Thickness – Depth of Inner panel
- Inner Panel acts as lock pillar & Hinge pillar
- Outer Panel is provided with holes for outside door handle

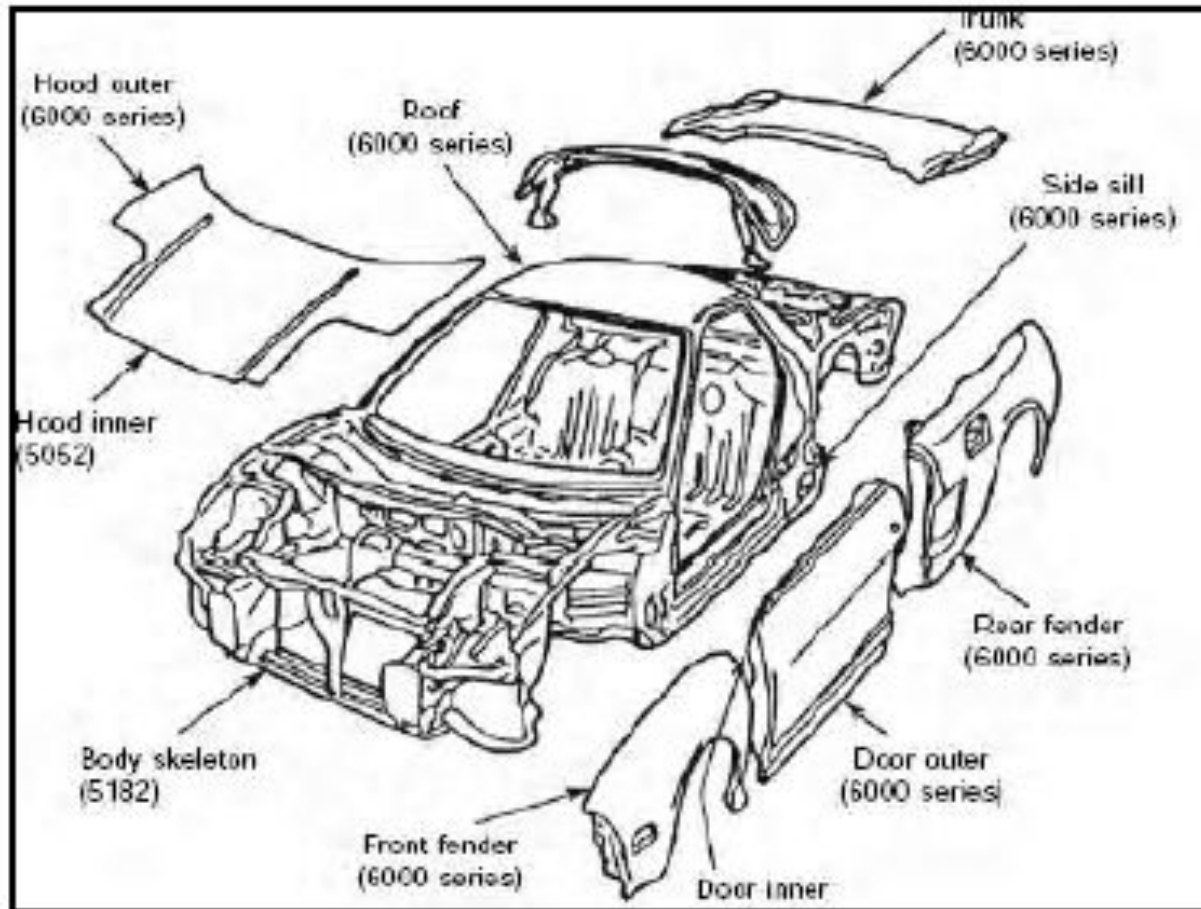


Major Body Panels/ Pressings

Doors

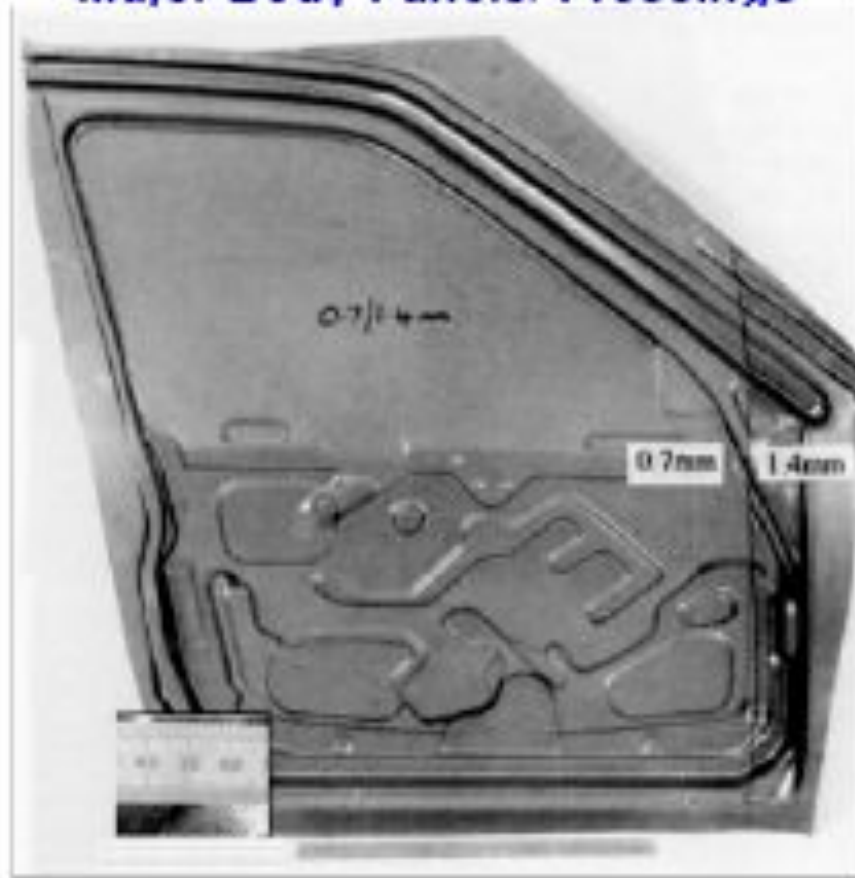
- Upper Portion of Door Closed with glass
- Raised & Lowered by Regulator Mechanism
- Trim Items – Items other than driving items for passenger comfort

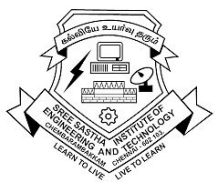




Door

Major Body Panels/ Pressings



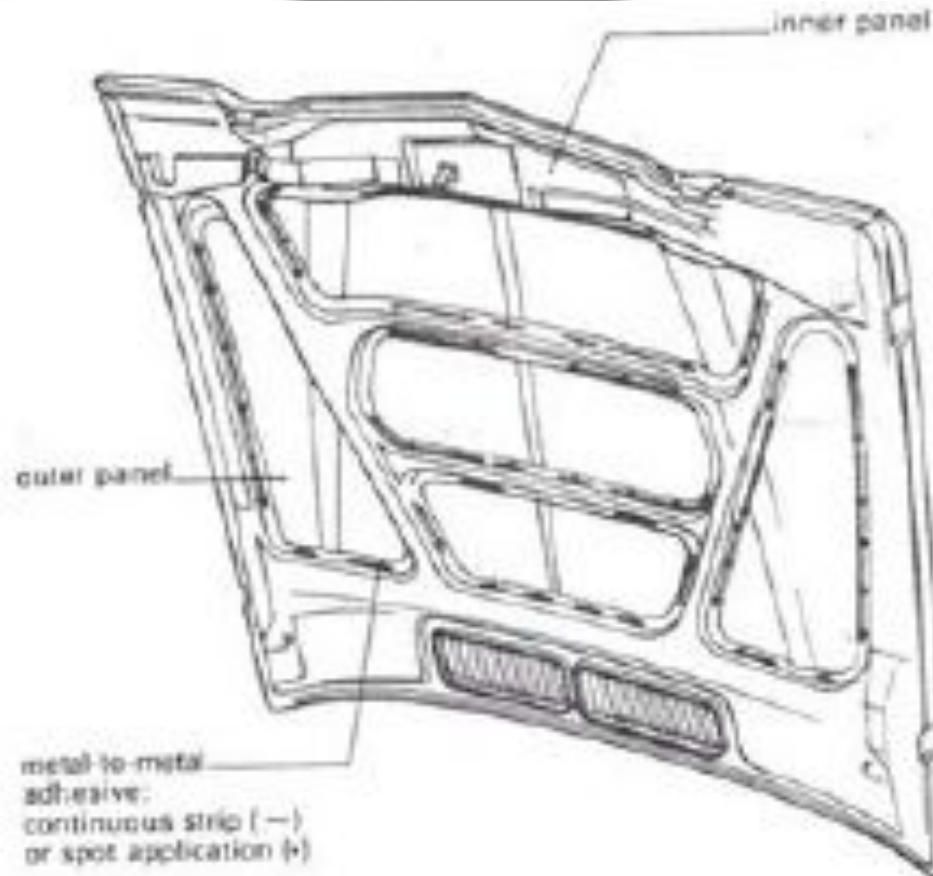


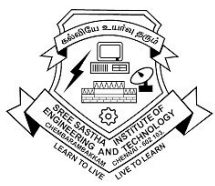
Major Body Panels/ Pressings

Rear Door/ Boot Lid

- For Accessing the Luggage Compartment
- Inner & Outer Panels
- External or Concealed Hinges
- Latch at the bottom controlled by exterior handle
- Some Models are not provided with handles ie hinges are spring loaded
- ie when unlocked raises part of the way and is held in open position

BONNET





Major Body Panels/ Pressings

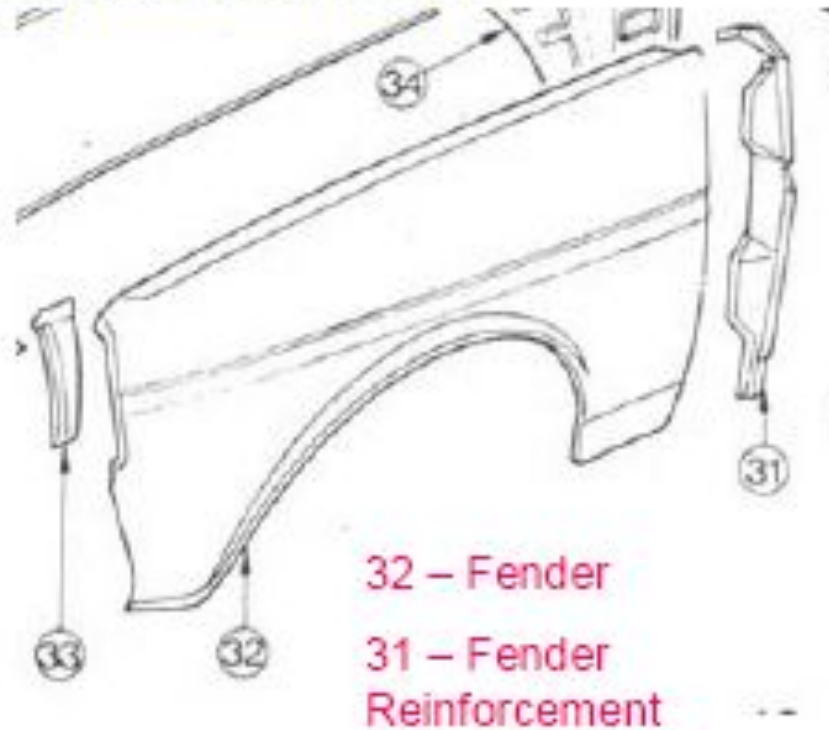
BONNET

- Panel Which Covers the Engine Compartment
- Common type - Mono or one piece type opened in different type
- Bonnet Latch Mechanism – depends on type of bonnet
 1. Hinged at the Front so rear end swings up when opened
 2. Opened from Either Side
 3. Unlatched at both sides & removed altogether
 4. Common - Alligator type , Hinged at rear, swings up from the front end. (Controlled from inside the car)

Major Body Panels/ Pressings

WINGS:

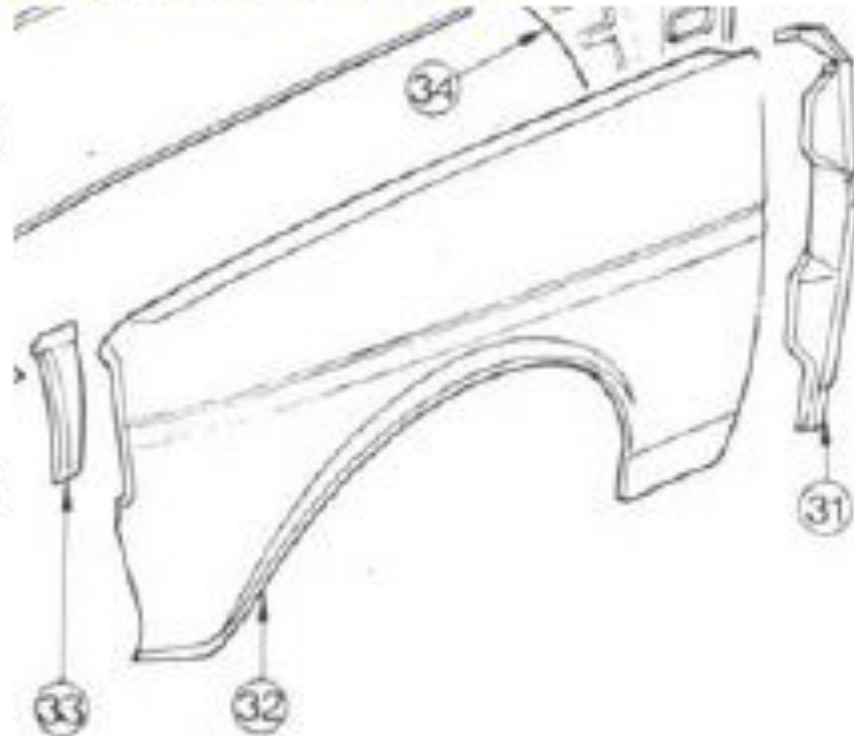
- Wings covers a wheel
- Car – 4 wings
- Covers **Suspension** , prevents **water & mud** from being thrown up on to the body by wheels
- Frt Wing –by flange
- Wing brackets – additional strength



Major Body Panels/ Pressings

WINGS:

- Recesses are provided on the front wing for head light & side light
- Rear wing /Frt Wing – Bolted to the body
- Rear Wing is a integral Part of the rear quarter panel



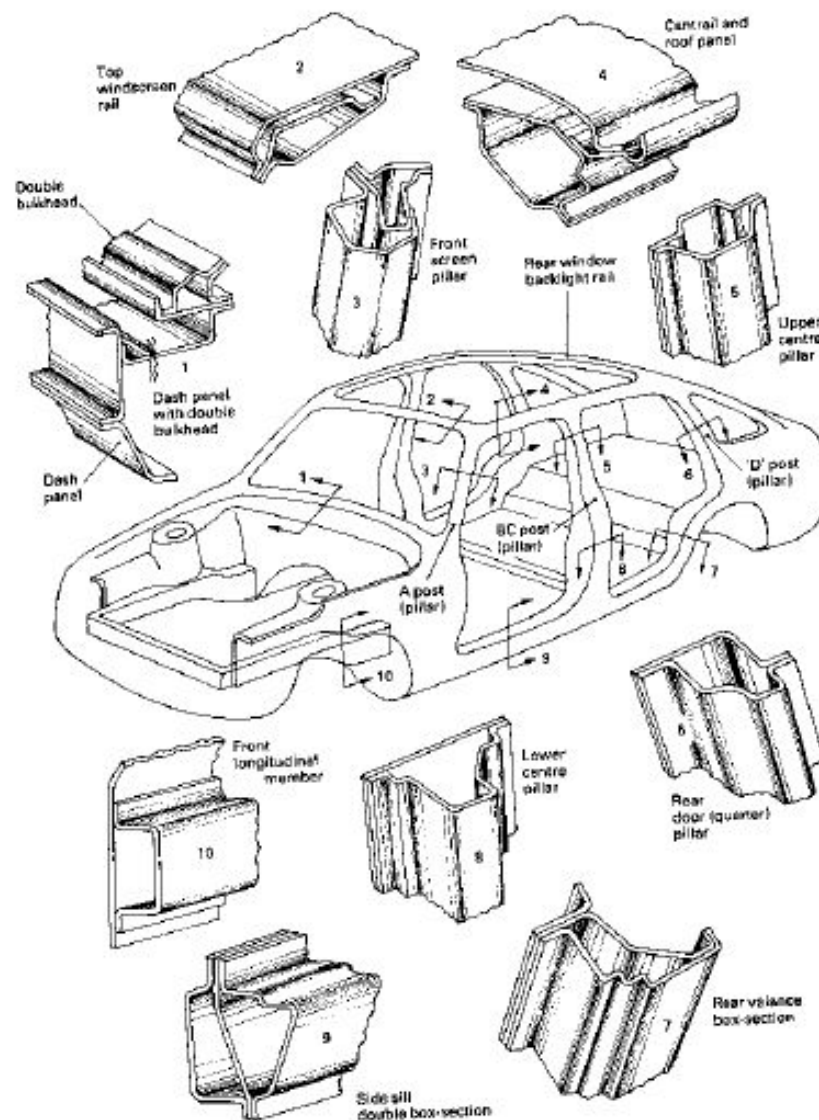
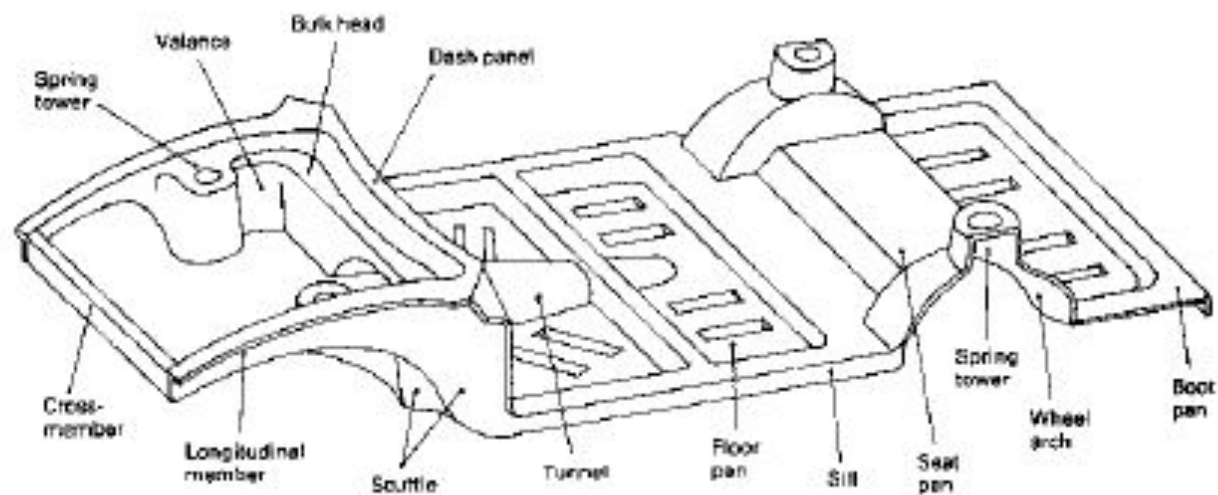
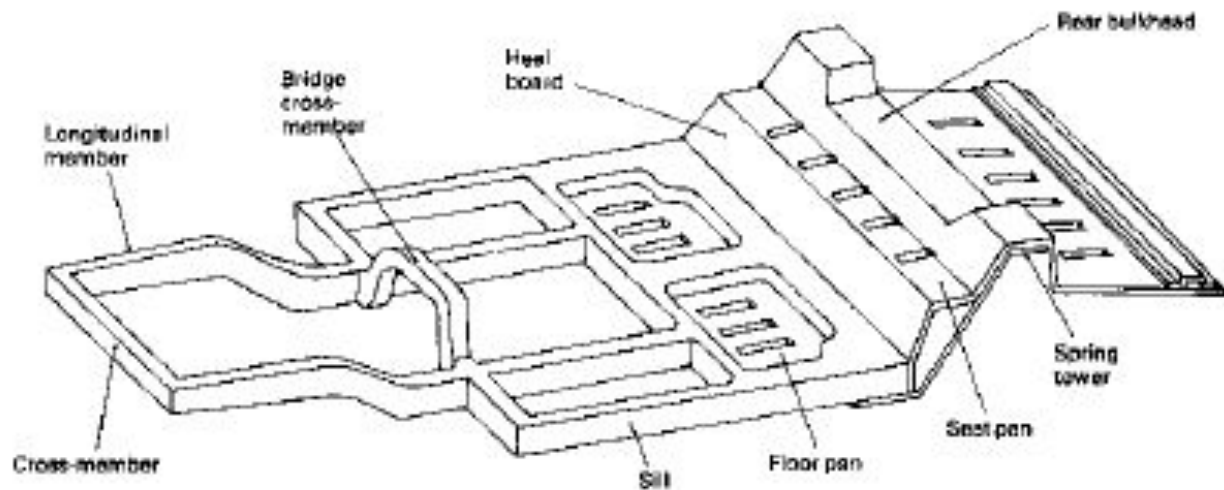


Fig. 1.2 Load bearing body box-section members



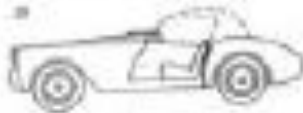
(a) Small central tunnel, sills, from valance, rear wheel arches and all round spring towers



(c) Longitudinal front members, sill, rear seat pan with bulkhead and spring towers

Fig. 1.3 (a–c) Platform chassis





Different Car Body Types : a-Four door saloon , b-Two door saloon , c-Three door saloon ,
d-Sports coupe , e-Coupe , f-Limousine , g-Estate car , h-Convertible , i-Roadster , j-Convertible
Limousine , k-saloon with roll back roof , l-Saloon with sliding roof , m-Torpedo or Spyder ,
n-Coupe de ville , o-Landaulet.

Historical Body Styles

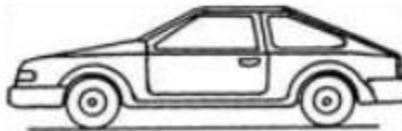


1.1.0. TYPES OF CAR BODY

Cars have now been identified by their **body styles** and **size**.

There are **different types of body styles** available in India

- × 1. Saloon or Sedan
- × i) Four door saloon
- × ii) Two door saloon
- × iii) Pillar less saloon
- × iv) Hatch back
- × v) Fast back
- × vi) Notch back
- × 2. Convertibles
- × 3. Limousine
- × 4. Estate car
- × 5. Sports Coupe
- × 6. Coupe
- × 7. Multi-utility vehicle or Multi-purpose vehicle.



Coupe



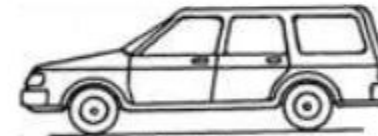
Saloon car



Four door saloon



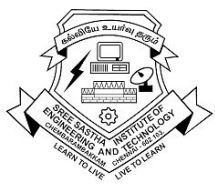
Hatch back



Estate car



Limousine
c.coomarasamy



See figure:

Types of bodies: shell forming the exterior of a car.

Hatchback: two-door passenger compartment with a door at the back.

Sports car: small, two-seated automobile.

Four-door sedan: passenger compartment with four doors and four side windows.

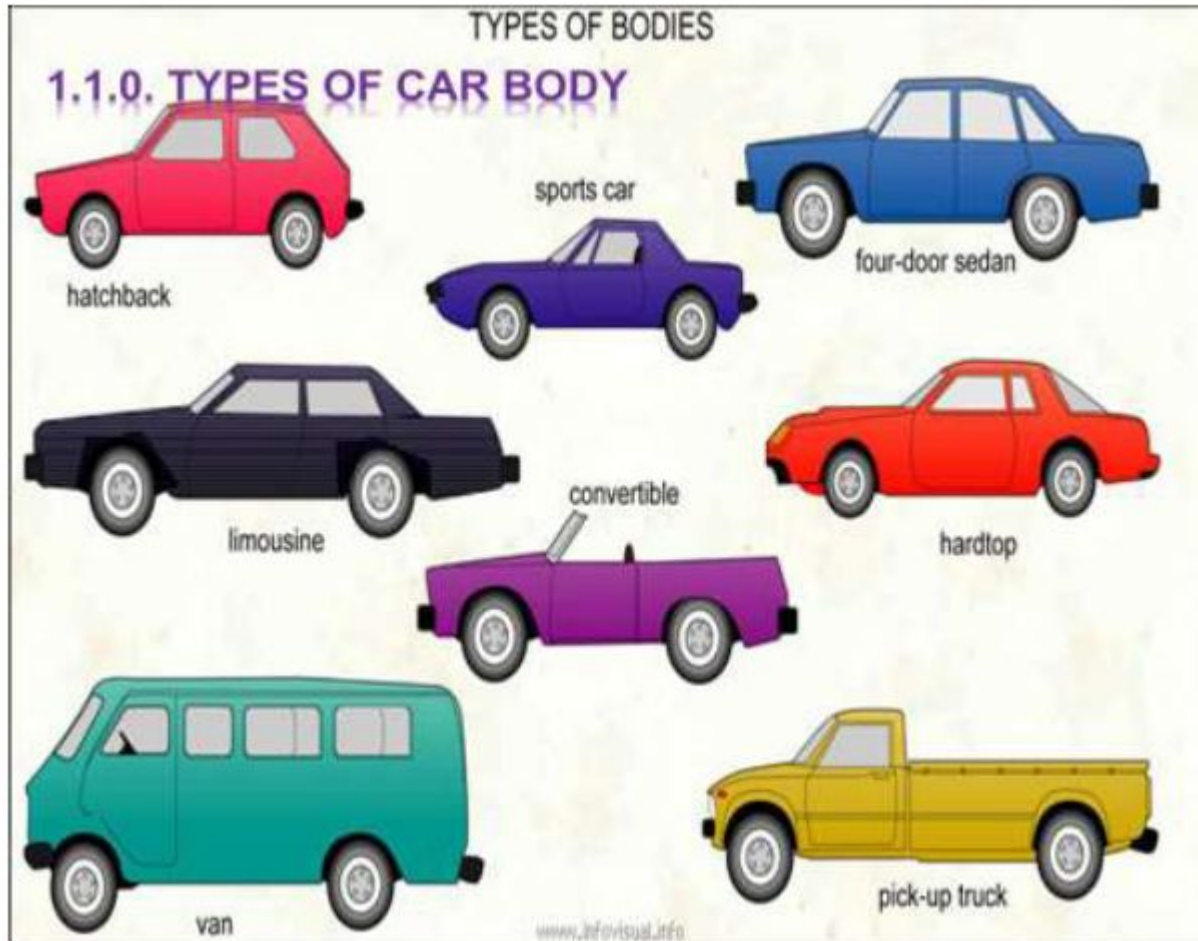
Limousine: large, six-seated passenger compartment.

Convertible: car with a removable roof.

Hardtop: two-door passenger compartment.

Van: small vehicle used to carry baggage; a small van.

Pick-up truck: a small truck.



Car Body Styles:

(i) Closed Cars:

- **Saloon:** Two or Four Doors, Single Compartment with two rows of seat. One at front another at rear, separate luggage space, most common passenger car, good HVAC, well designed seats, $C_d = 0.35$ to 0.50
- **Hatchback:** Saloon with a door at the back



SEDAN OR SALOON

A sedan car (American English) or saloon car (British English) is a passenger car with two rows of seats and adequate passenger space in the rear compartment for adult passengers. The vehicle usually has a separate rear trunk (boot in British English) for luggage, although some manufacturers such as Chevrolet and Volkswagen have made rear-engined models. It is one of the most common body styles for modern automobiles.

SEDAN OR SALOON



3_box_design

Hatchback

Hatchback (a.k.a. liftback) sedans typically have the fastback profile, but instead of a trunk lid, the entire back of the vehicle lifts up (using a liftgate or hatch).

A vehicle with four passenger doors and a liftgate at the rear can be called a four-door hatchback, four-door hatchback sedan, or five-door sedan. An example of such is the **Chevrolet Malibu Maxx**. Examples of this design are the **Volkswagen Golf**, and **Chevrolet Chevette**.

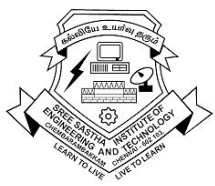
- Coupe: Saloon with roofline at decreased height. One row of seats for two person .Only two doors are provided



•Limousine: Driving Compartment is separated from rear compartment by a sliding glass division. luxury car, High Quality Equipment & Finish



American _vip _limousines



1.1.3. LIMOUSINE

- × The **term now** refers to a
- × luxury sedan or saloon car, especially one with a lengthened wheelbase or driven by a chauffeur.
- × The chassis of a limousine may have been extended by the manufacturer or by an independent coachbuilder.
- × These are called "stretch" limousines and are traditionally black or white.
- × Limousines are usually liveried vehicles, driven by professional chauffeurs.
- × As the most expensive form of automobile ground transportation, limousines are culturally associated with extreme wealth or power and are commonly cited as examples of conspicuous consumption.
- × Among the less wealthy, limousines are often hired during special events (most commonly weddings, proms, and bachelor parties).

A limousine (or limo) was **originally** an "enclosed automobile with **open driver's seat**," and was named from the **French *limousine*** (in the Occitan language) that was originally an adjective referring to a **region in central France**.

The **automobile** meaning evolving from a type of **cloak and hood** that was worn by the **inhabitants of the Limousine region** that later resembled the **covering of a carriage** and much later used to describe an **automobile body** with a **permanent top** that extended over the open driver's compartment.



- × It is a **luxurious car**.
- × A high roof line to allow **better head room** for seating five persons **comfortable** behind the driver.
- × A high quality equipment and finish and **luxurious interiors**,
- × **Cushioned seats**,
- × **Air-conditioning system**,
- × **Cooling classes**, etc.,
- × Also it can provide **partition** between the driver and the rear passengers.



1.1.3. LIMOUSINE



AT 8801 VBE - Mr P.M.Subramanain

Designed by 123FreeVectors.com
Asst Prof SSJET

(ii) Open Cars:

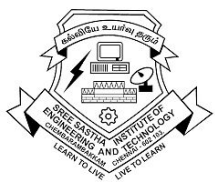
- Sports: Two door or less, provided with a collapsible hood
- Fold flat windscreen – **Torpedoes or Spyders**



hydrofoilcar3BAR_468x302_sports

- Convertible: Foldable Type Roofs
- But wind up windows





1.1.2. CONVERTIBLES

- × **Convertibles** have either **two** or **four doors**, come with **flexible** operating roof.
- × If the **top** is made of **strong** or **rigid material** as **steel**, it is called **retractable hardtop**.
- × With the press of a button it can be converted into **coupe** or **convertible**.
- × The **collapsible roof section** is usually made from **flexible canvas** or **vinyl** or an **articulated folding frame**.
- × Now most of the modern vehicles come with an **electrical retraction mechanism**.
- × When the **top** is **erected** it is secured to the **windshield frame header** with **automatic** or **manual latches**.
- × e.g., BMW Z4, Audi R8 Spyder, Porsche Boxster
[Read more: <http://www.motortrend.in/autonews.htm#ixzz2Y5AZawOA>]

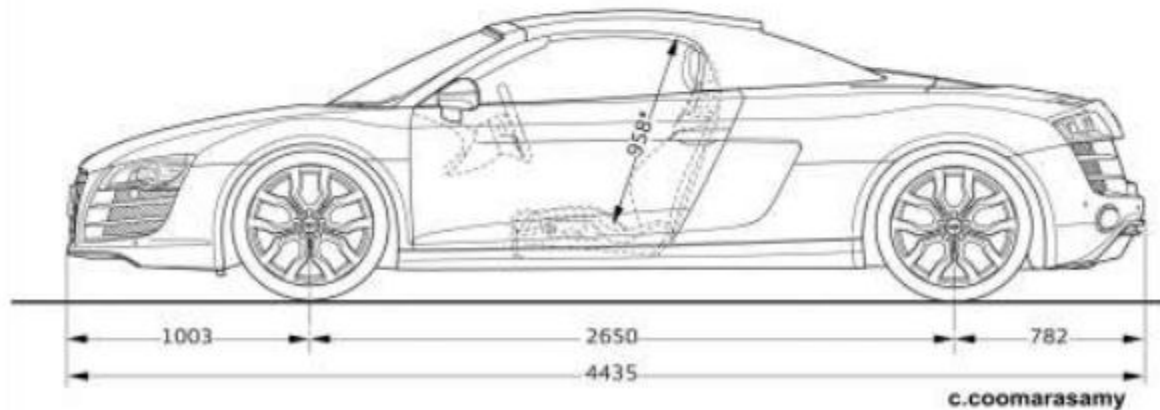
1.1.2. CONVERTIBLES



BMW Z4



Audi R8 Spyder : 2010



1.1.2. CONVERTIBLES

- × **Porsche Boxster** comes in last for visibility, but improves when roof is opened



Roadster :

Roadster is 2-seater lightweight cars **without a permanent top** usually are **sporty convertibles**.

Roadster can also have **more than two seats** with **transferable roof**.

(iii) Special Cars:

- Estate Car: Saloon Car, Passenger roof extended right up to rear end.
- More luggage space & longer wheel base -



Neocho_p_estate_car

Estate Car: other names Universal, Kombi & Station Wagon, Touring & picnics

Estate Cars

Estate Cars or Station Wagons are family cars with an extended rear boot area.

Offering more cargo capacity than a standard sedan, they are a popular alternative to a family car.

We feature consumer reviews of Estate Cars, covering Audi estate cars, BMW Touring estate cars and many more, giving you all the information you need to choose your next Estate Car.

1.1.4. ESTATE CAR / VAN

- × An estate car (or station wagon, as it is known in America) is very popular with families who have pets (often dogs).
- × In essence, they are very similar to a saloon car, because they have a large amount of passenger space.
- × However, while a **saloon car** will have **little or no cargo space**, an estate car will have a **large boot space** – that can, in most estate cars, be extended into **seats for more passengers**.
- × The **boot space** on an **estate car** can be accessed by a **fifth door**.
- × This door, depending on the model of the car, can either be accessed by a **vertical-lifting door**, or a **simple car door at the rear**.



1.1.4. ESTATE CAR / VAN

- × A **station wagon** (also known as an **estate** or **estate car**) is an automobile with a body style variant of a sedan/saloon with its roof extended rearward over a shared passenger/cargo volume with access at the back via a third or fifth door (the liftgate or tailgate), instead of a trunk lid.
- × The **body style** transforms a **standard three-box design** into a **two-box design**—to include an A, B, and C-pillar, as well as a D-pillar.
- × Station wagons can flexibly reconfigure their interior volume via **fold-down rear seats** to **prioritize either passenger or cargo volume**.
- × Various other names are **Kombi, camping brake**, etc.,

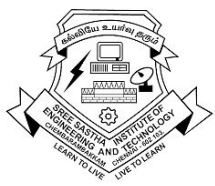
Examples of estates/station wagons:
Hyundai i40 Tourer
Jaguar XF Sportbrake
Mercedes-Benz CLS Shooting Brake



Station Wagon: Wood panelled body, and it has same look like steel structure

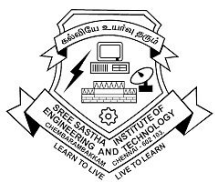


118942.1971.Buick.Sport.Wagon.4-Door.Station



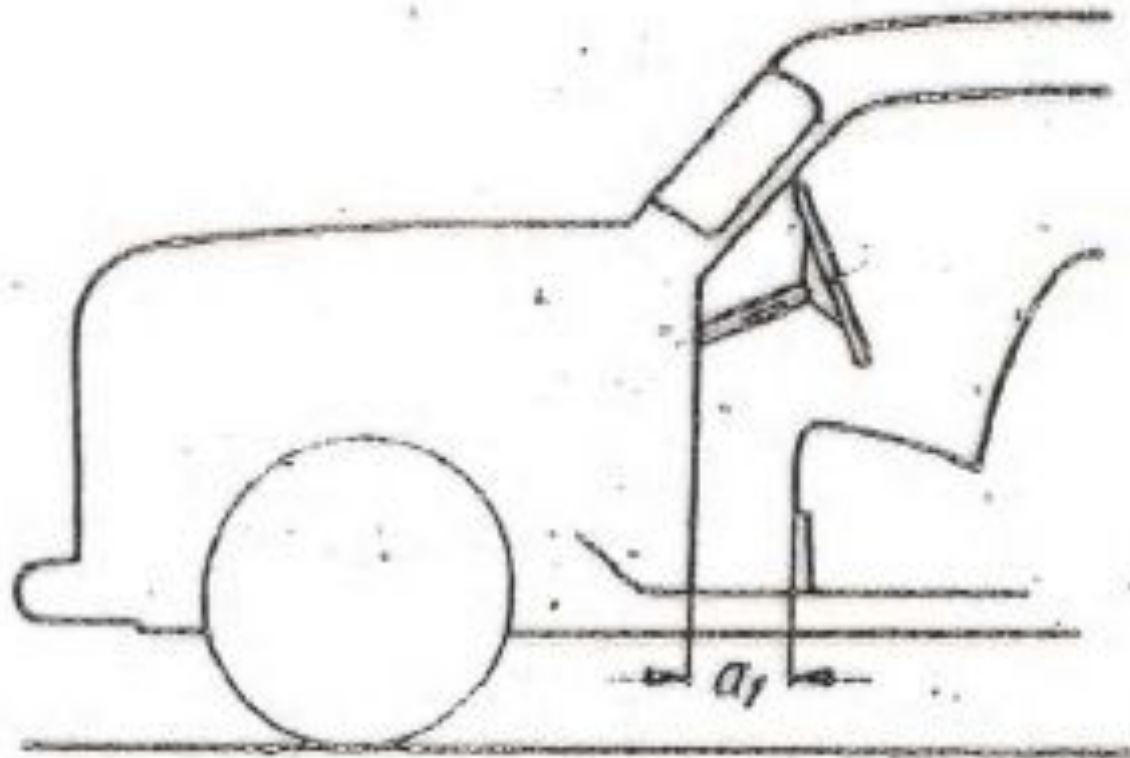
DRIVER'S VISIBILITY

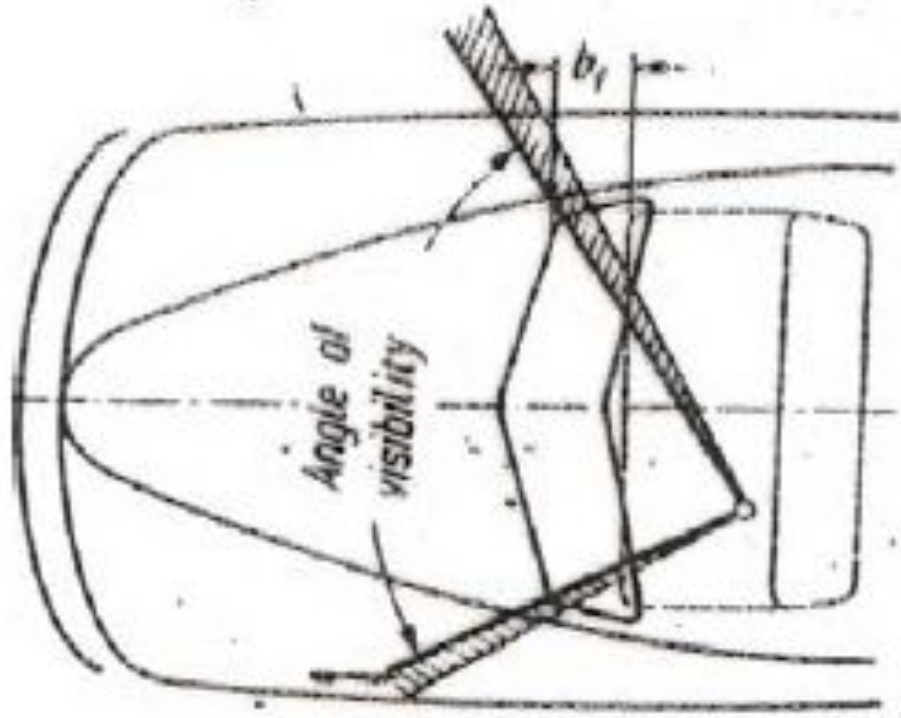
- 2 Aspects – Ability to see & Ability to be seen
- Body Design Requirement – Good All Round Visibility
- Driver visibility is the maximum distance at which the driver of a vehicle can see and identify prominent objects around the vehicle
- Visibility is primarily determined by **weather conditions and by a vehicle's design.**
- The parts of a vehicle that influence visibility include the **windshield, the dashboard and the pillars**
- Good driver visibility is essential to safe road traffic.

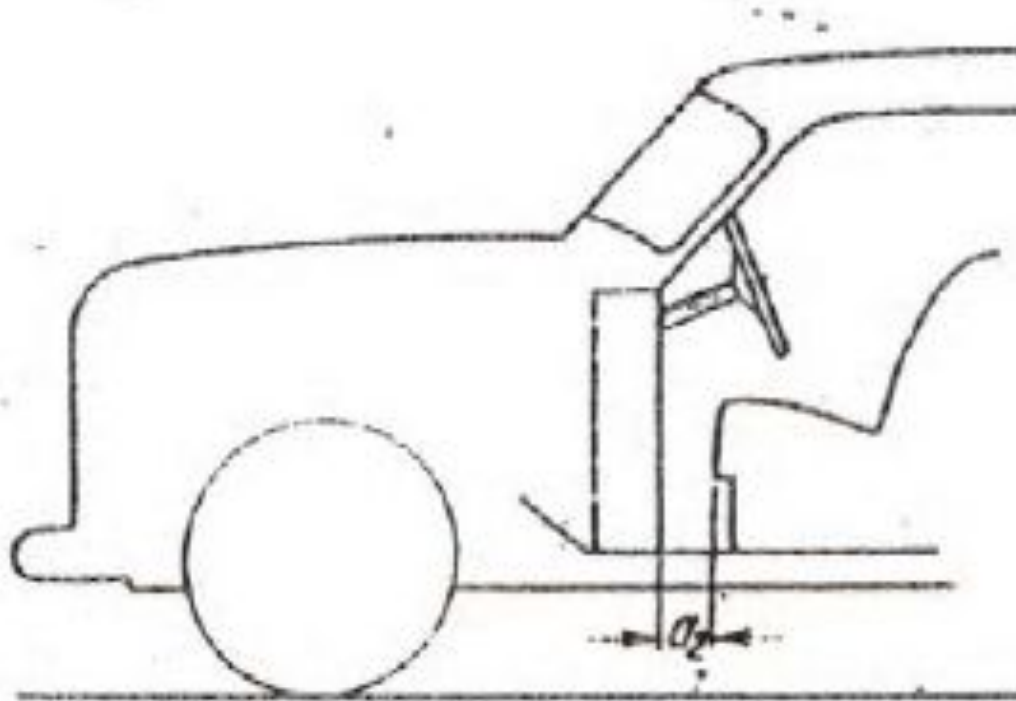


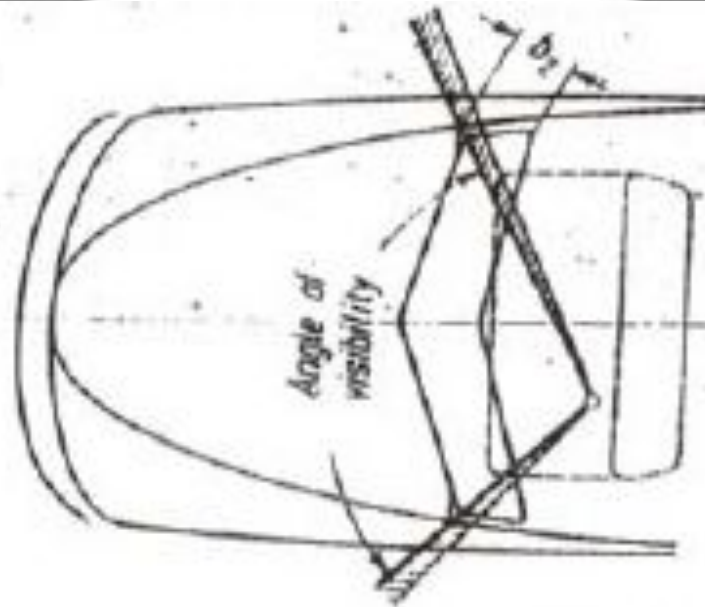
DRIVER'S VISIBILITY

- Windscreen, Window opening size & their position relative to the occupants decide visibility
- **Blind Area** – must be as low as possible
- Increase in Glazed area – Results in reduced strength of vehicle body structure
- Occupants are placed close to windscreen , **Forward visibility** is considerably improved but entry & exit will become difficult – dimension b/w pillar & seat will get reduced
- Entry & Exit will be made easier – by suitably shaping the door at the expense of more **complicated structure**.







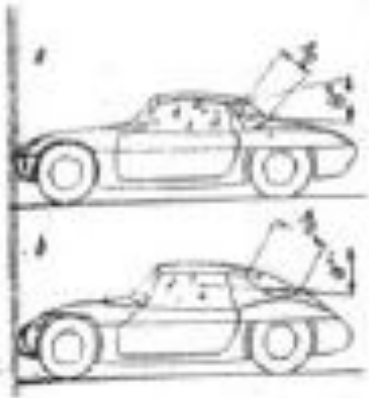


**Improved frontal visibility obtained
by moving driver closer to windscreen**

DRIVER'S VISIBILITY_ REGULATIONS

- **Military Vehicle** – Downward Visibility important – **Driver must be positioned as high as possible** in relation to the lower edge of the windscreen
- **Upward angle of vertical visibility** – driver able to see the traffic lights, direction indicators
- **Rearward Visibility**- more importance , increased glass area
- **Vertical position of signal lights – too low** –can't be easily seen, applicable to front lights also – lower position make them invisible in the rear view mirror

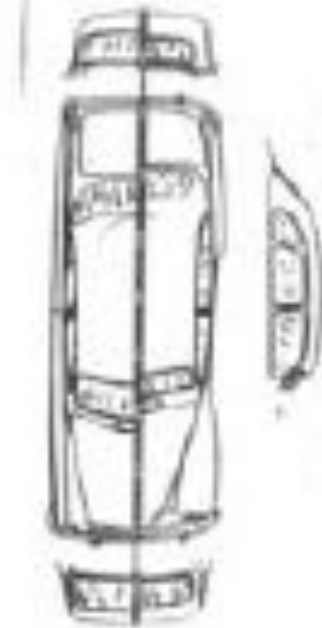
DRIVER'S REAR VISIBILITY



Rearward Visibility- more importance , increased glass area are required to maintain a given **rear view vertical angle with a fast back window.**

Rear Visibility : Depth of rear window (h_a & h_b) depends on body shape to ensure the same subtended angle of visibility

Driver's visibility



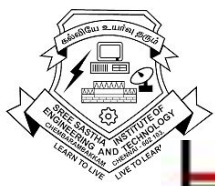
Comparison of glass area between
Old and New models



Horizontal visibility - shaded area gives the blind
area for driver (Varies from 92% visibility and
8% blind area)

DRIVER'S VISIBILITY

- **Blind spots** may occur in the front of the driver when the A-pillar (also called the windshield pillar), side-view mirror, and interior rear-view mirror block a driver's view of the road.
- Behind the driver, there are **additional Pillars, headrests, passengers, and cargo**, that may reduce visibility.
- Blind Area - parameter for Vehicle Comparison
- Sum of arcs where there is zero visibility is 8% of 360 deg

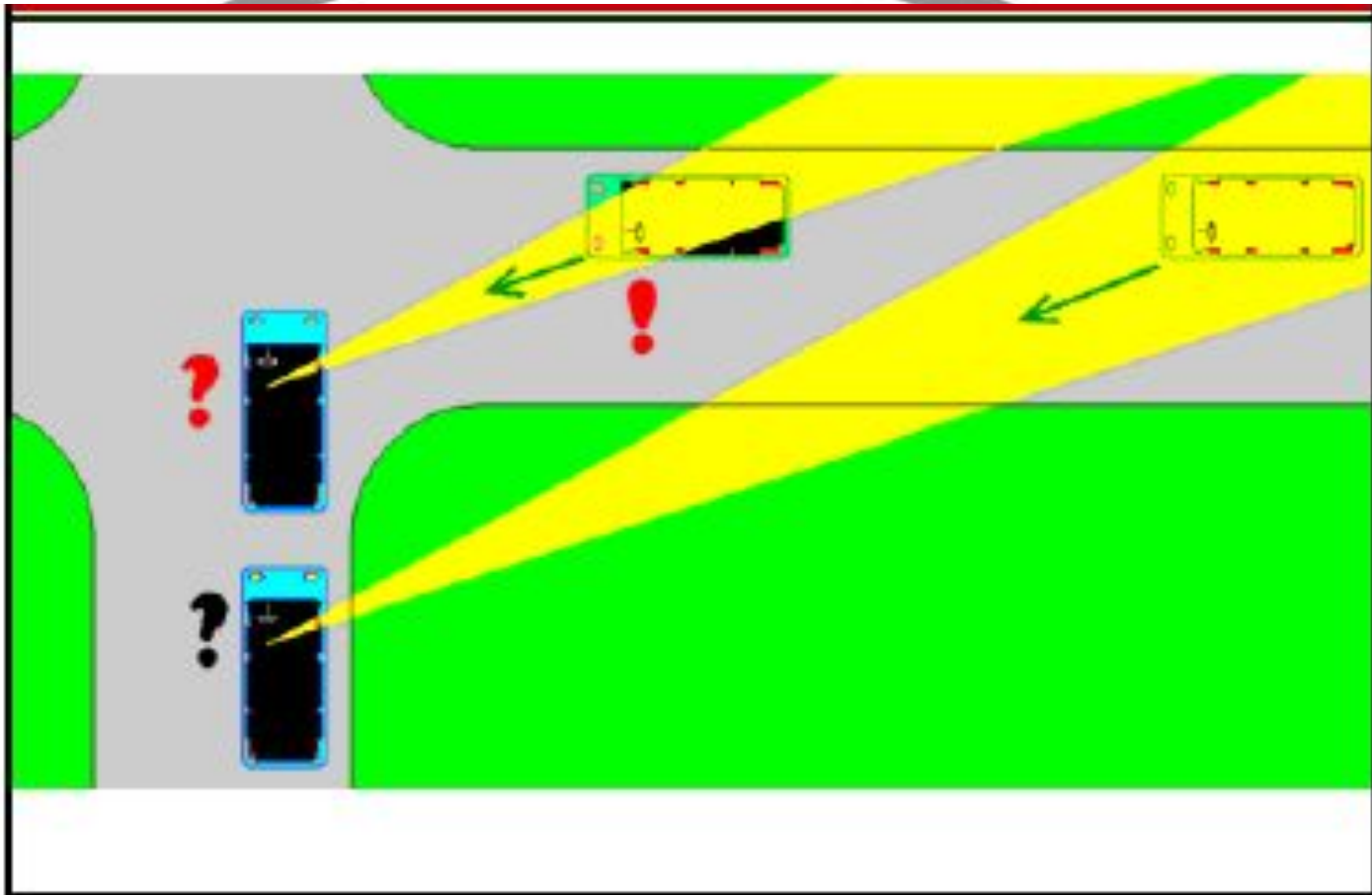


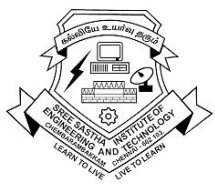
Forward visibility

The front-end blind spots caused by this can create problems in traffic situations, such as in **roundabouts, intersections, and road crossings.**

Front-end blind spots are influenced by the following design criteria:

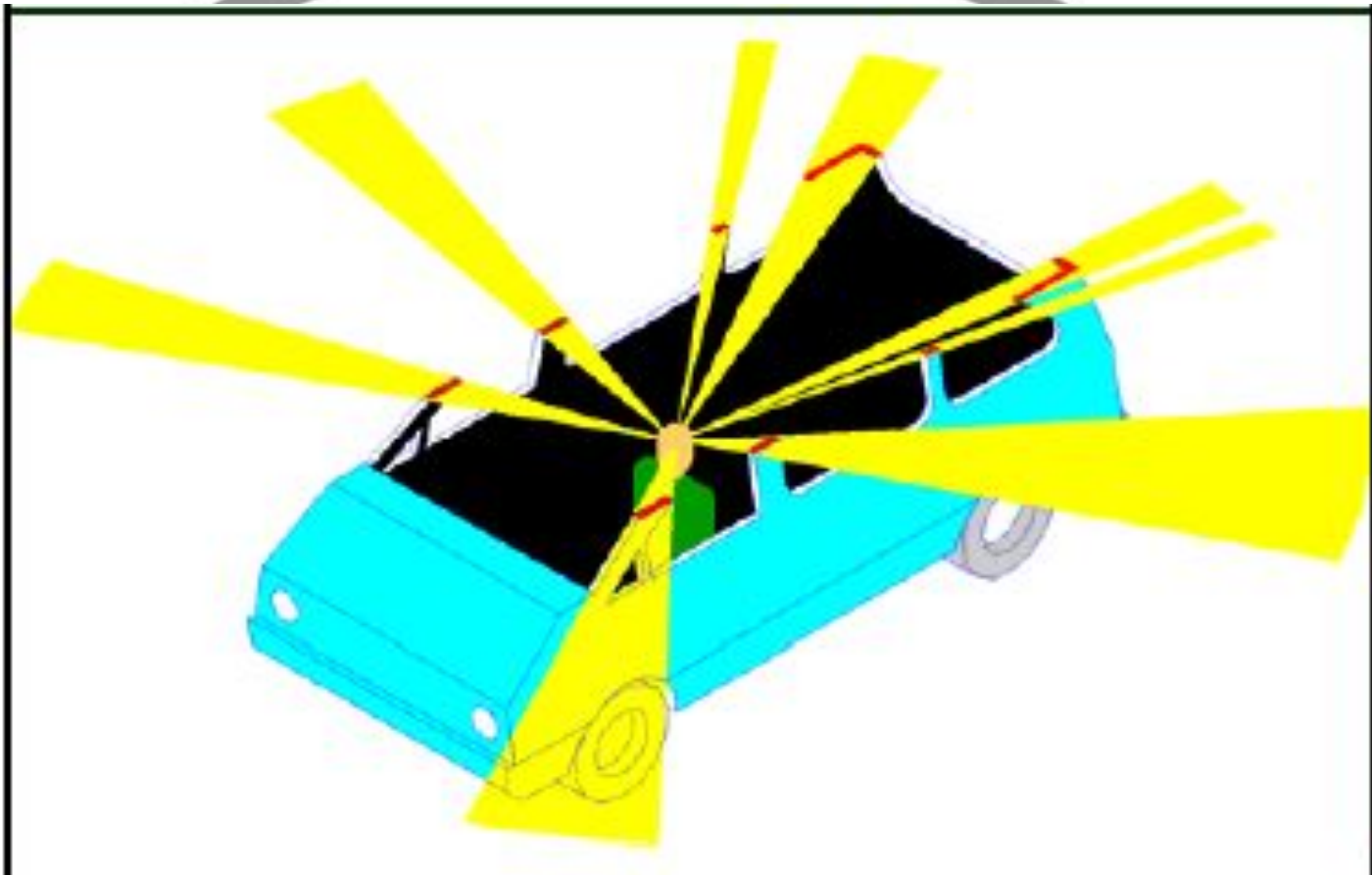
- Distance between the driver and the pillar
- Thickness of the pillar
- The angle of the pillar in a vertical plane side view
- The angle of the pillar in a vertical plane front view
- the form of the pillar straight or arc-form
- Angle of the windshield
- Height of the driver in relation to the dashboard

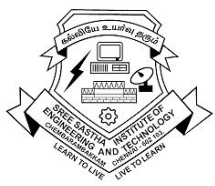




Effects of A-pillar angle on visibility

- Most passenger cars have a diagonal pillar as shown in this side view.
- The angle between the horizon and A-pillar is **approximately 40 degrees** with a straight pillar that is not too thick.
- This gives the car a strong, aerodynamic body with an adequately-sized front door.





Effects of Windshield on visibility

- The sides of a windshield are curved, which makes it possible to **design vertical A-pillars** that give the driver **maximum forward visibility**
- the more vertical the A-pillar is,
- the less space the door opening has, and
- the greater **frontal area and coefficient of drag** .

eg

Honda Step Bus Concept

Saab 900

School bus

Almost all Cadillacs from 1954-1959

Effects of Drivers Height on visibility

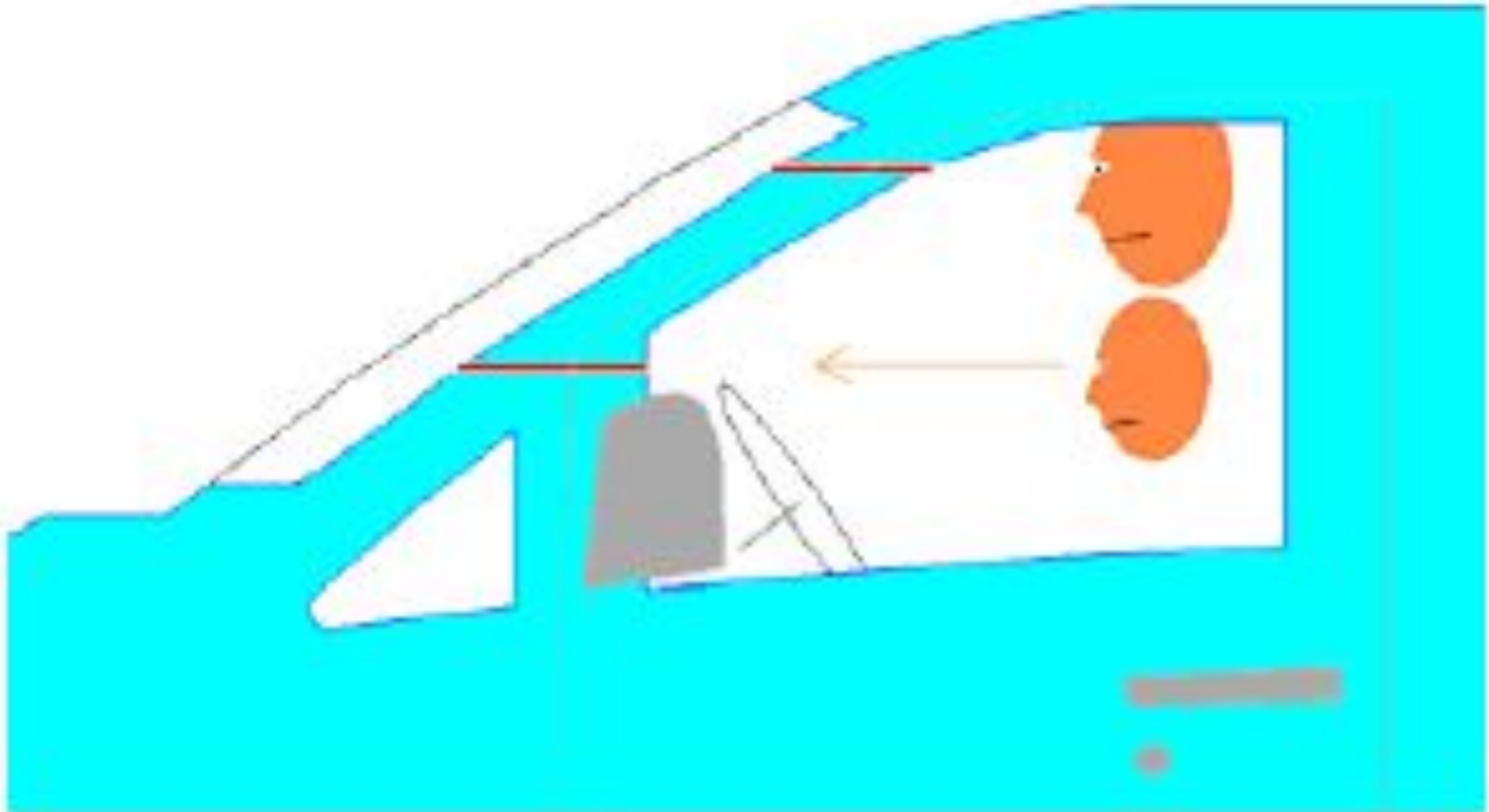
- Driver height can also affect visibility.
- An A-pillar that is split up and has a small triangle window (Front Quarter glass) can give a short driver visibility problems.

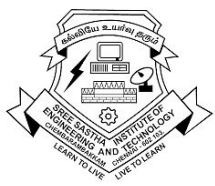
Some cars the windshield is fillet with the roof-line with a big radius. A fillet round A-pillar can give a tall driver visibility problems.

the A-pillar can block the driver from seeing **motorcyclists** &

the B-pillar (car) can block the vision of a tall driver in small 4 door cars.

Effects of Drivers Height on visibility





Effects of Drivers Height on visibility

- Turning your head reduces blind spot
- A driver may reduce the size of a blind spot or eliminate it completely by **turning their head in the direction of the obstruction.**
- This allows the driver to **see better around the obstruction** and allows the driver better depth perception.

Dashboard reflection

dashboard has a **non-reflecting dark colored surface**.

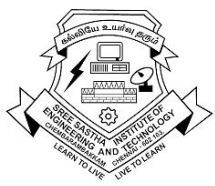
A small dashboard gives some **reflection on the lower part of the windshield**.

A big dashboard can give **reflection on eye height**.

A-pillar reflection

It is best if the inside of the A-pillar has a non-reflecting dark colored surface.

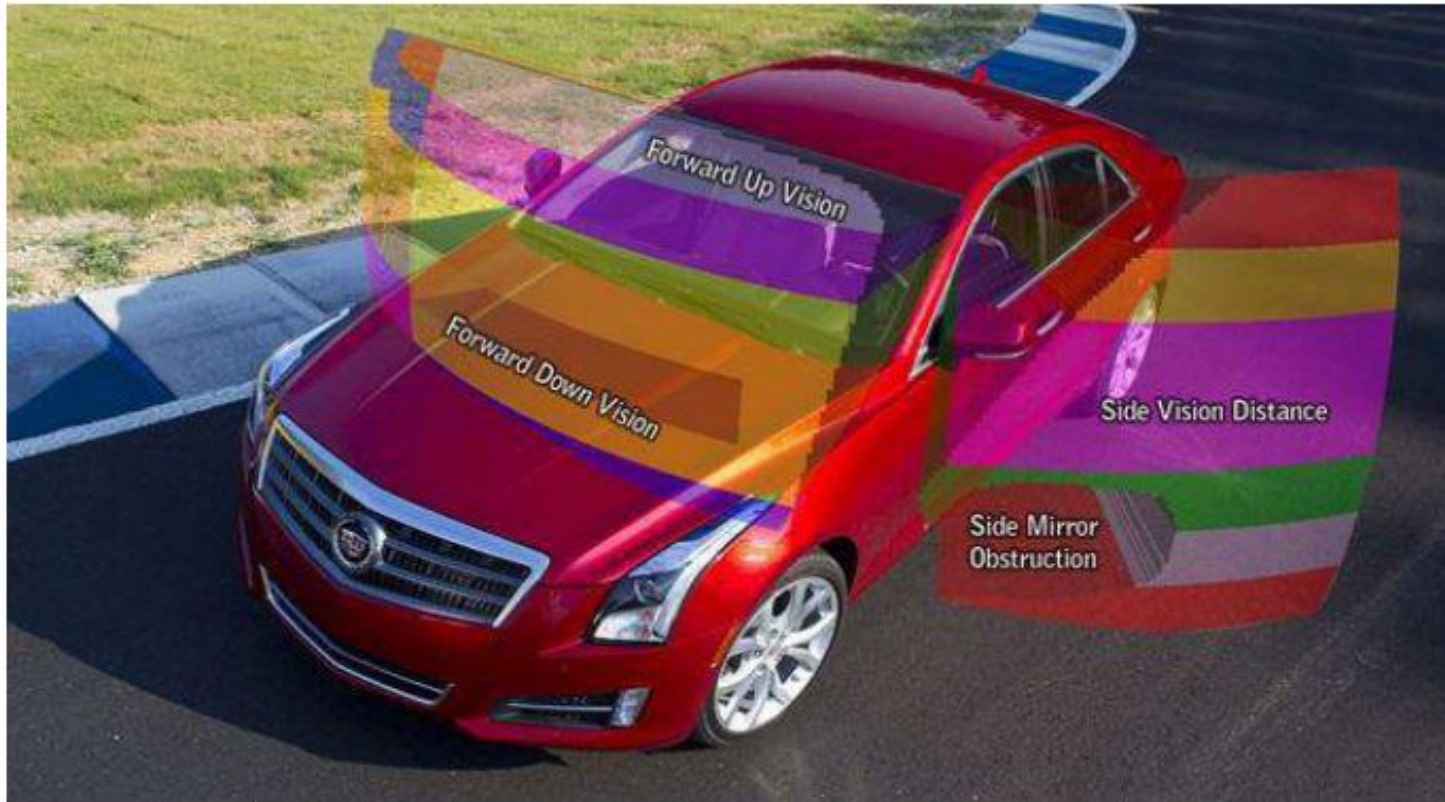
If the side of the window is curved there is less A-pillar reflection.

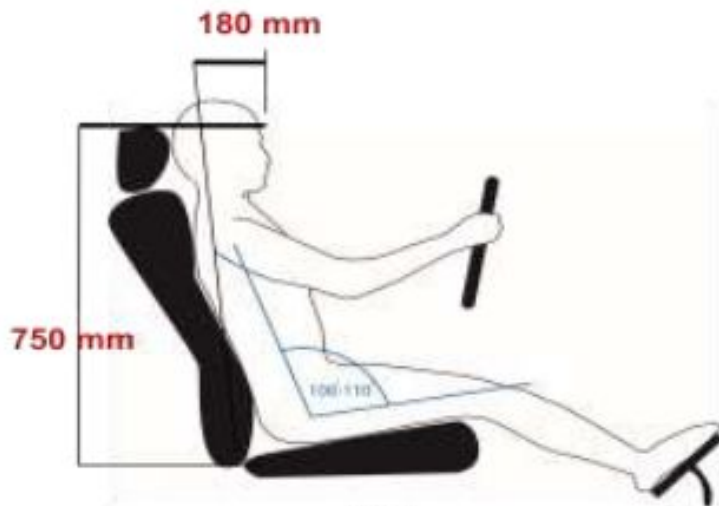


Light through roof reflection

Some new model cars have a very big roof-window.

Sometimes the sunlight through the roof lights up the dashboard and gives a reflection in the windshield

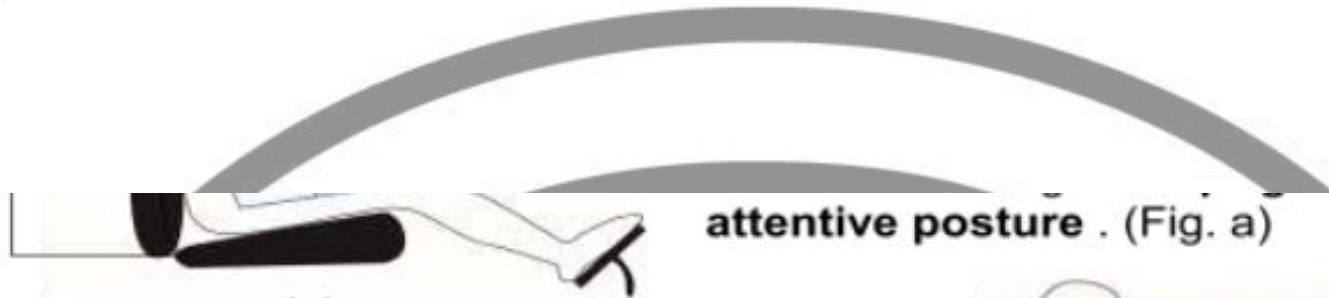


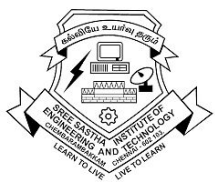


(a)
Eye position of average driver

While most people do actually **adjust** the **angle** of the **seat back** when in the **driver's seat**, **not many do it properly**. It is **easy** to become to **laid back** or **uptight** in the **driver's seat**. **Recline** the **back** between **100° -110°**. This angle **supports your upper body** while maintaining and **upright** and **attentive posture** . (Fig. a)







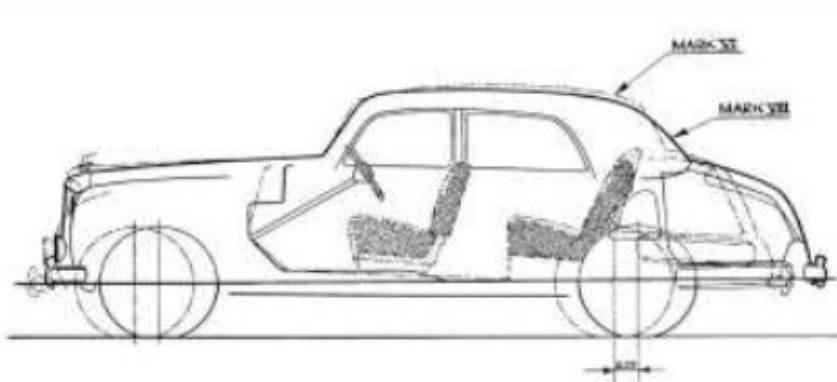
1.2.1.VISIBILITY REGULATIONS

Key human factor issues

- × **spatial arrangement** of driver's/ passenger's seats,
- × **reachability of the occupants** towards various controls (gear, accelerator, clutch, break , various knobs and switches etc.)
- × **force requirement** for operating controls
- × **comfort/ discomfort during driving** or for sitting for long duration
- × **visualization of displays/dials** or controls inside vehicle
- × visibility towards road ahead or vision through rear view mirrors
- × **various clearance dimensions**
(leg room, head room, lateral clearance etc.)
- × **environmental conditions**
(noise level, temperature, humidity etc.) and so on.

1.2.1. VISIBILITY REGULATIONS

- ✖ Presently, vehicle manufacturers follow various standard recommended dimensions for their design.
- ✖ **Standards provided by Society of Automotive Engineers (SAE Standards) are widely followed.**
- ✖ In the present module, one case study of ergonomic evaluation of a vehicle workstation with an individual on driver seat has been depicted to provide an idea how vehicle workstation can be evaluated for various human factor issues.



BENTLEY MKXII & MKXIII SUPERIMPOSED

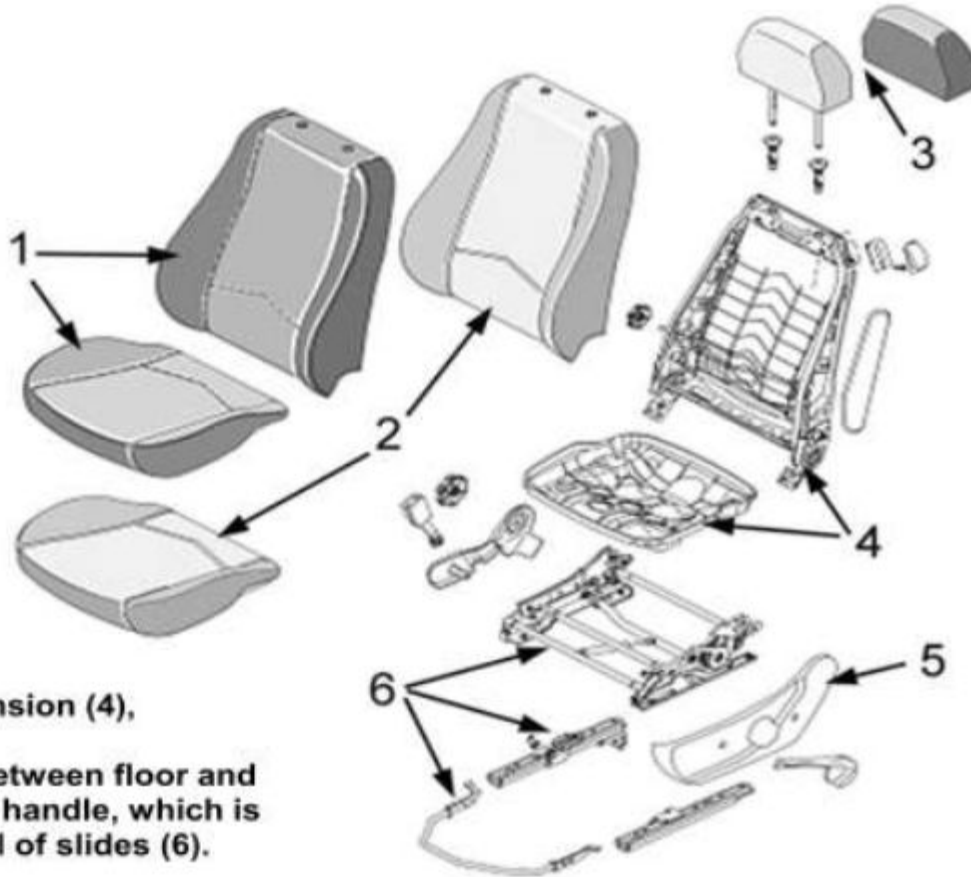


c.coomarasamy

SEAT

Seat Components

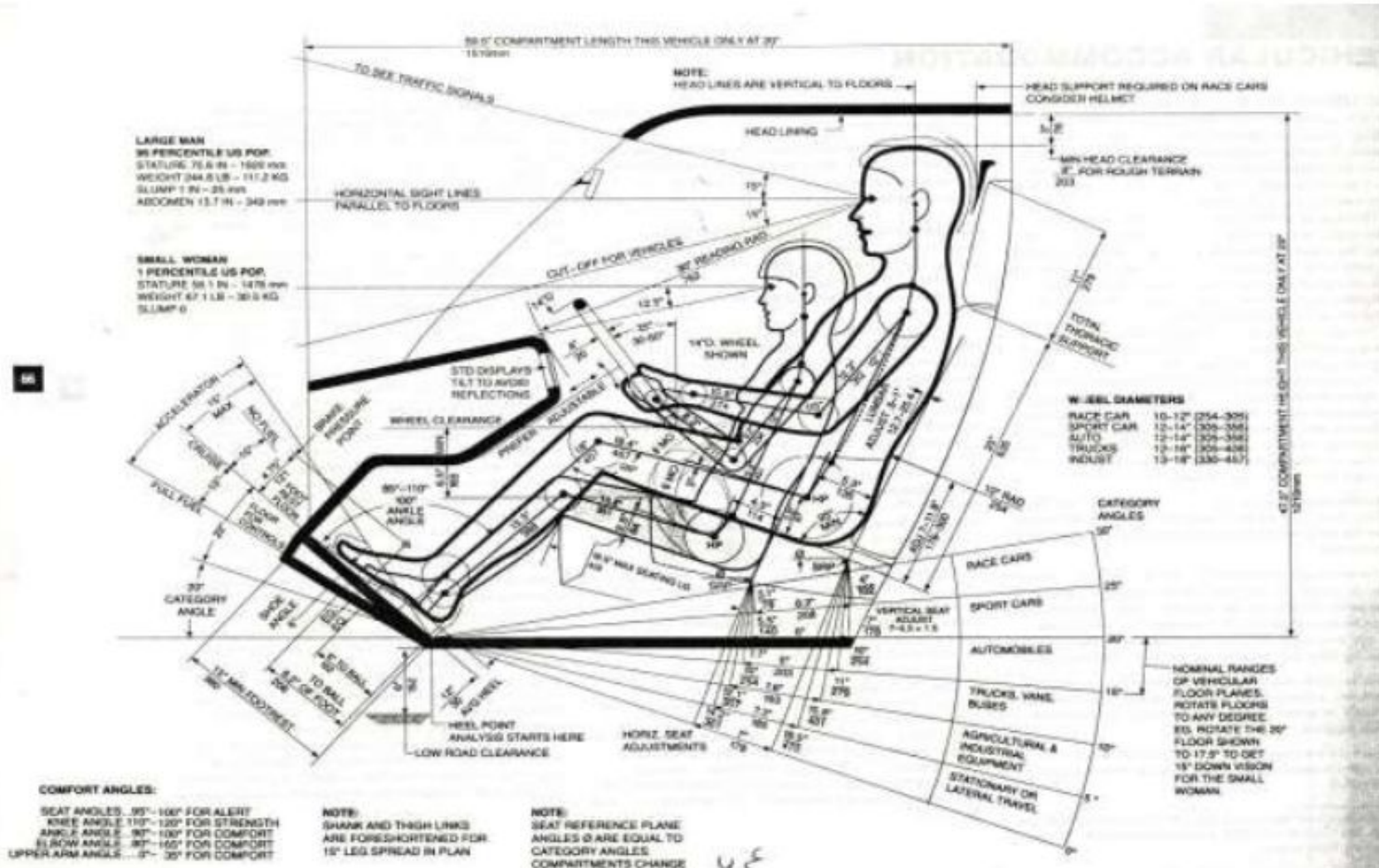
covers (1),
foams (2),
headrest (3),
structure and suspension (4),
plastic trim (5),
interface structure between floor and mechanisms, slides, handle, which is the activation control of slides (6).



- ✗ A correct driving position is important in the vehicle layout, and the seating position in relation to the steering wheel, foot controls and other secondary controls is of fundamental importance in body design.
- ✗ Seating position has an influence not only on the driver's comfort but also on the road safety.
- ✗ At the design stage a celluloid model is most often used.
- ✗ The driver's seat should be adjustable- 45 mm horizontally and 30 mm vertically.

1. Sit upright and well back in the seat.
2. Adjust the position of the seat forward or backward to ensure the pedals can be reached and easily depressed to the extent required.
3. Adjust the seatback so that the controls are easily operable.
4. Adjust the tilt and telescopic positions of the steering wheel downward so the airbag is facing your chest.
5. Lock the head restraint in place with the center of the head restraint closest to the top of your ears.
6. Wear the seat belt correctly.

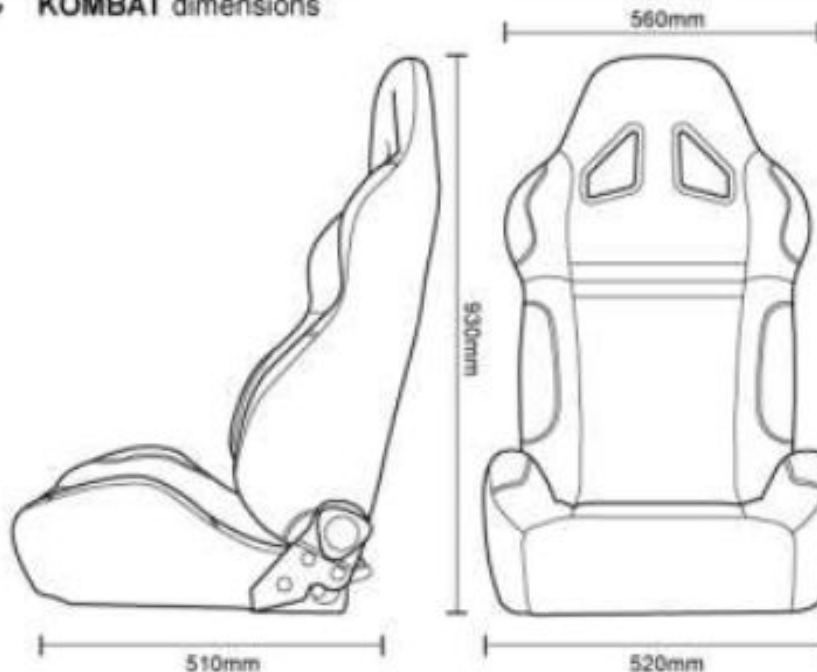




Geometrical relations of driver's seat

Class of vehicle	Cushion height above floor	Angle of cushion inclination	Angle of backrest inclination	Max. force on the pedals
	h (mm)	α	α	(kg)
Saloon	300-340	12	100	66
Light commercial	340-380	10	98	70
Normal control truck	400-470	9	96	74
Forward control truck	430-500	7	92	82

e.g., KOMBAT dimensions



All SAAS seats have been tested to meet
ADR 3/02 - Seats and Seat Anchorages 2005

1. ADR 3/02 5.5.1.1 & 5.5.2 Seat and Seat Anchorages Longitudinal 20 "g" Test
2. ADR 3/02 5.5.3 Seat Rearward Backrest Test
3. ADR 3/02 6.4 Seat Energy Dissipation Test
4. ADR 22/00 Head Restraints Test

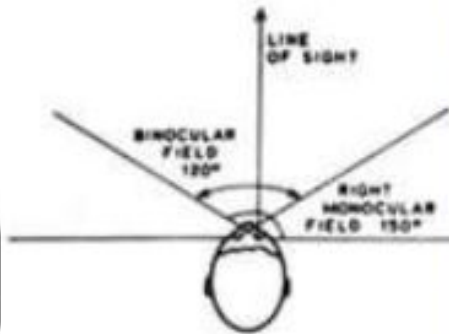
*A.D.R certificate is available upon request.

1.2.2. DRIVER'S VISIBILITY

× Limits of Visual Field:

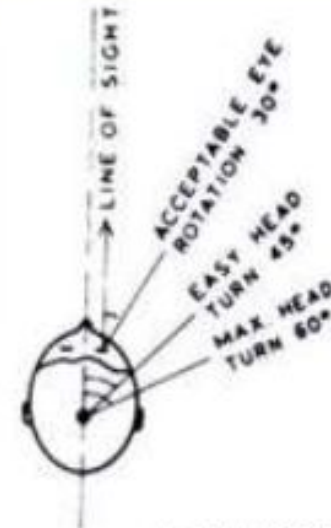
Driver can turn **both eyes** and **head** to gain a **wider field of view**, and moreover can make use of **peripheral vision** to see objects or **movements** even **without** turning eyes.

In the **horizontal plane**, the **binocular field of view** extends **some 120 degrees**, as in figure given below .



Vision is **sharp only** over **a fairly small area** directly **ahead**. So, eyes need to be turned to focus on objects outside the foveal (central vision) area.

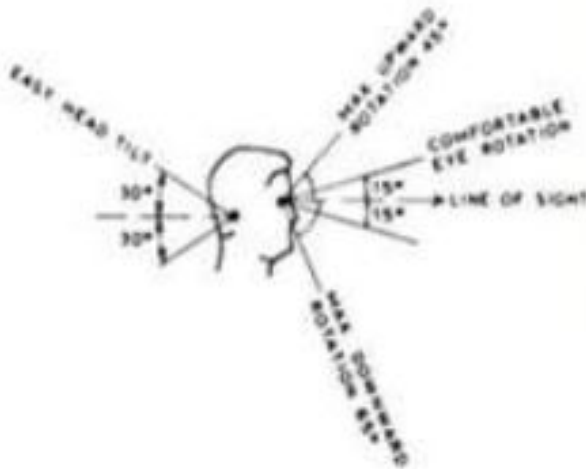
According to SAE J985 eyes generally **only turn by about 30 degrees before the head is turned**, which can comfortably give a **further 45 degrees view to either side**.



c.coomarasamy

1.2.2. DRIVER'S VISIBILITY

- × In the vertical plane eye movement (fig.) is comfortable within 15 degrees above or below the horizontal, although the eye can see up to 45 degrees upward or 65 degrees downward if necessary.



On the other hand, head can **easily** incline 30 degrees upward or downward.

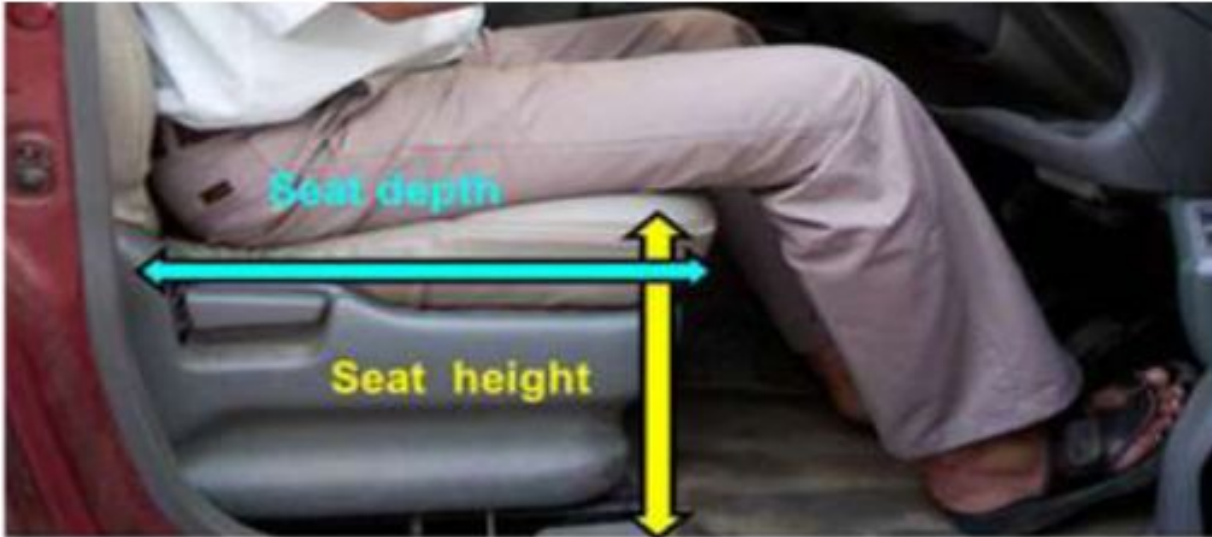
Thus, by movement of head and eye, the driver can have **extended direct field view**.

The driver has to concentrate on **direct view**, that is **on road**.

So glancing away from the road for a **short period** is **possible**.

Mirror and **other instruments** should be **close** to the driver, so that driver **does not require** a much head and eye turn to have a look.

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Sitting Accommodation:

All the seat dimensions (seat cushion depth, width and height, backrest with and height; head rest dimensions) should be acceptable.

Sitting Accommodation:

All the seat dimensions (seat cushion depth, width and height, backrest with and height; head rest dimensions) should be acceptable.

More over due to various adjustable features of the seat one can adjust backrest angle/position of headrest, position of seat etc. as per his/her requirement



VISIBILITY REGULATIONS

Sitting and Driving Comfort:

Adopted driving posture by the individual should show that angles at various body joints are in comfort range as defined by Porter and Gyi (1998).



Clearance Dimensions:

- **Headroom:**

The headroom for the vehicle should be sufficient for uses to avoid head striking with roof during jolts/ jerks.

c.coomarasamy

VISIBILITY REGULATIONS

• Leg room:

The legroom for the vehicle should be sufficient for users for normal pedal operation.

There is no collision between:

- Seat front edge with popliteal area (behind knee) of lower leg,
- Thigh/knee with steering wheel/dashboard



VISIBILITY REGULATIONS

Lateral Clearance:

Observation:

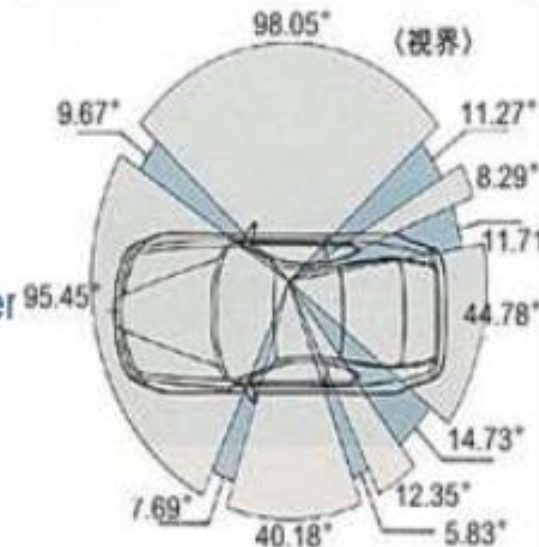
Left side and right side lateral clearance for the driver seat should be sufficient.



1.2.2. DRIVER'S VISIBILITY

- × During **automobile design**, **care** should be **taken** to **provide maximum view all around** either through **direct vision** or with **the help of devices** like **mirror** or **camera**.
- × It is also **important** to **ensure minimum visual obstruction** either by **vehicle components** or by **driver's own body parts**.
- × This is **particularly important** for **allowing unobstructed view** of the **displays** on the **dash board**.

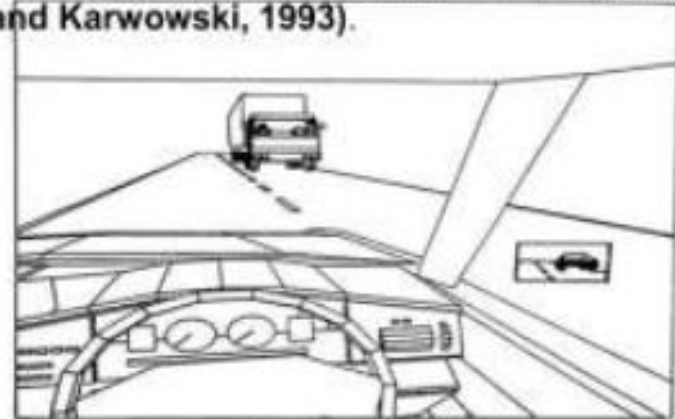
Visibility diagram for a 1991-era Honda Prelude:



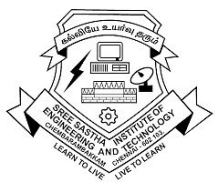
VISIBILITY

- × On the **road** **driver need much longer view** to anticipate and prepare for avoiding actions.
- × **Views close** to the **vehicle** is **equally important** when turning left or right and **maintain proper distance** to **avoid accidents**.
- × Fig. shows the **view inside the vehicle**, **forward** and **side views through glasses** and **rear view through mirror**.

View during driving (Adopted from Peacock and Karwowski, 1993).



Design Course on
Basic Ergonomics in Automotive design
The Fundamentals of Human-System
Interactions

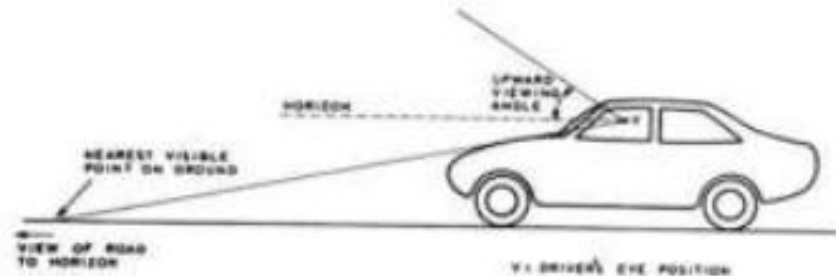
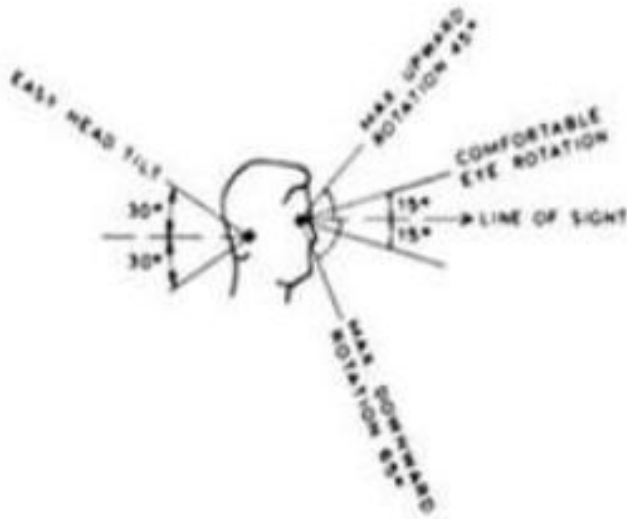


VISIBILITY

- × • Indirect View:
The views to the rear of the vehicle mainly obtained through the mirrors.
- × This view provides information on passing vehicle, vehicle close to the rear when the driver proposing to change the lane.
- × The reflected view of mirror can be represented in the same way as in direct view with the viewing angles.
- × The view of image is bounded by the frame of mirror.
- × The image boundaries can be determined by the mirror dimensions, locations of the mirror with respect to driver's eye and optical characteristic of mirror.
- × By adjusting the mirror the field of view of rear can be adjusted.

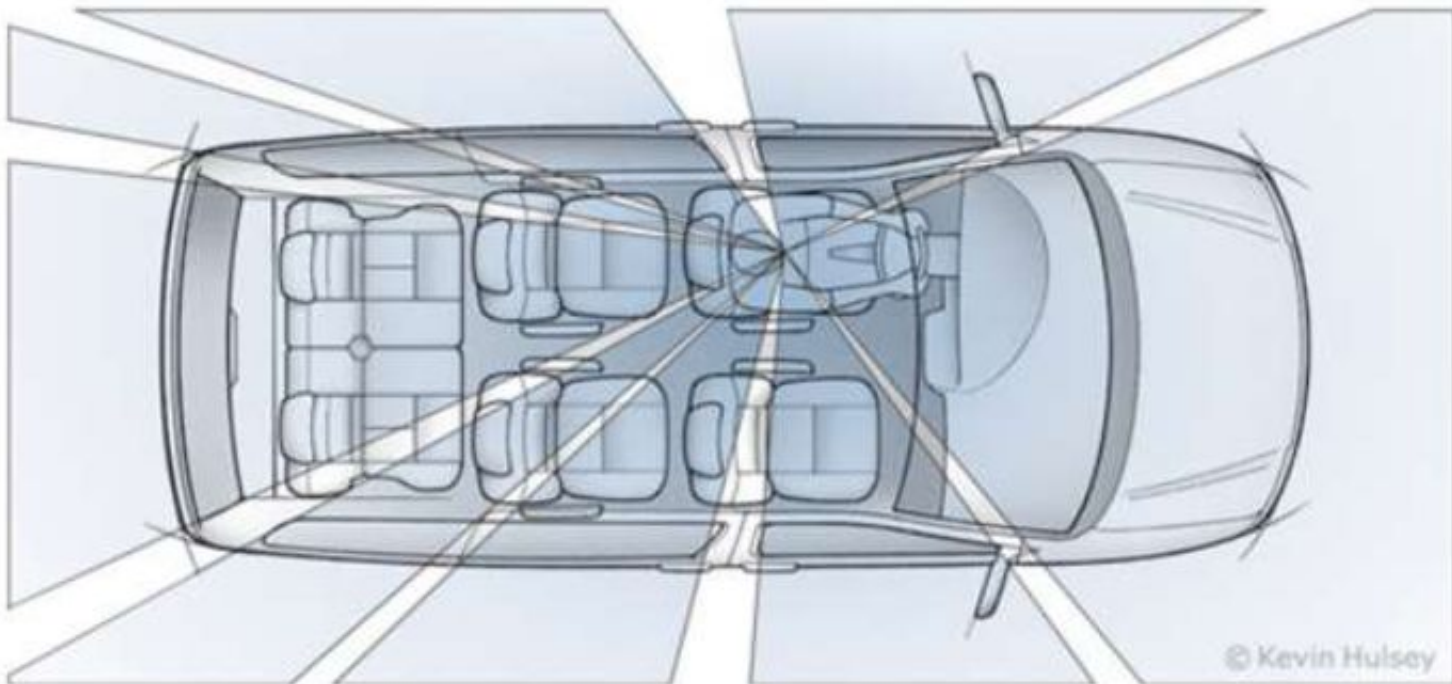
The downwards view can be considered for road. Height of the dashboard and curvature of the bonnet are the two determining factor for **downward view** through front windshield.

Upper edge of the dashboard should be **at least 15 degree below** that **horizontal eye line of driver** with smallest (5th percentile) sitting eye height. The far distance view is based on the horizon, the sightline passing through the driver's eye.



VISIBILITY

- ✖ This diagram shows a minivan's full range of driver visibility and door pillar blind spots in a 360 degree radius.

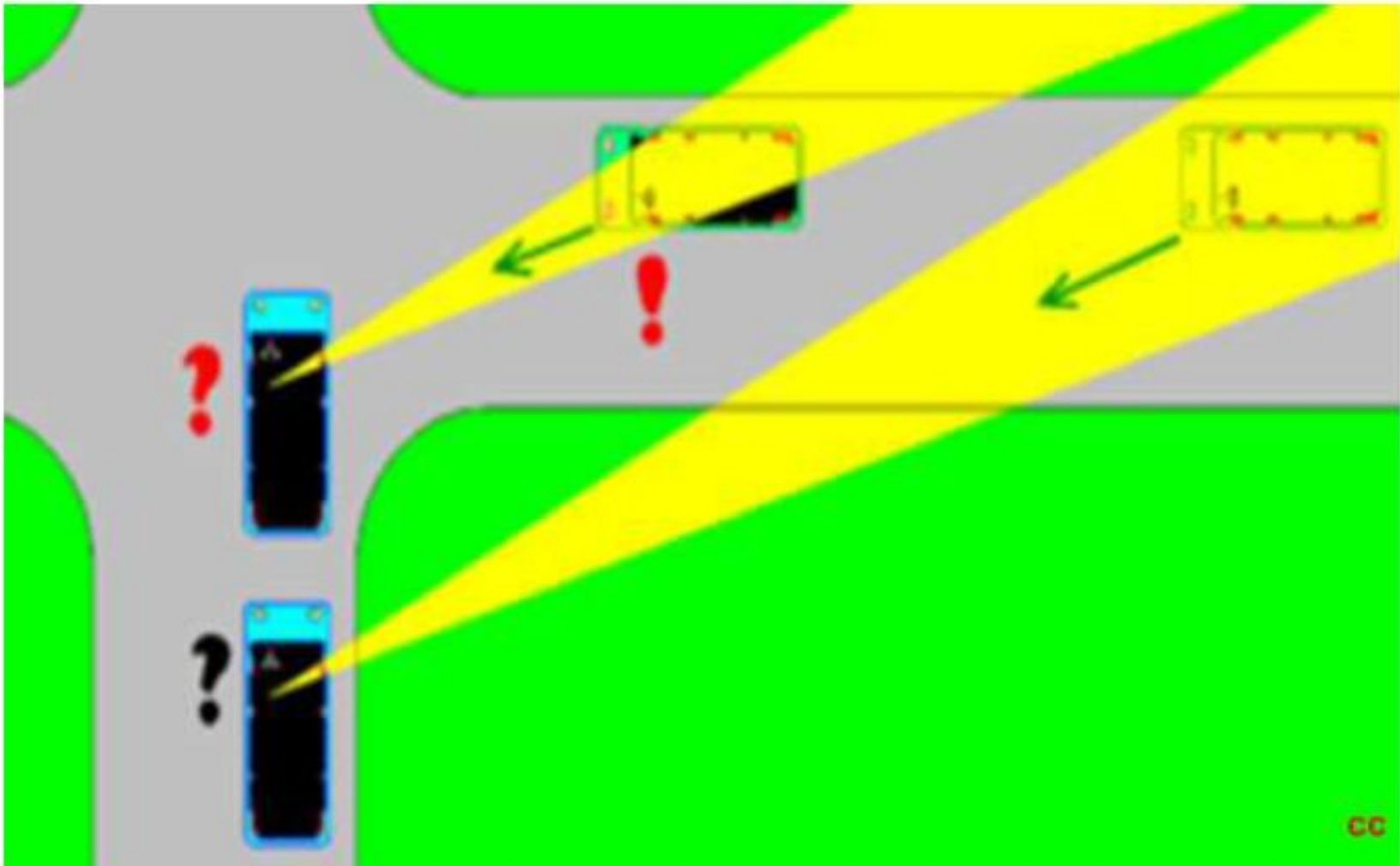




FORWARD VISIBILITY

- × This diagram shows the **blocked view** in a horizontal-plane in front of the driver.
- × The **front-end blind spots** caused by this can **create problems** in traffic situations, such as in roundabouts, intersections, and road crossings.
- × Front-end blind spots are **influenced by the following design criteria**:
 - × **Distance between the driver and the pillar**
 - × **Thickness** of the pillar
 - × The **angle** of the **pillar** in a **vertical plane side view**
 - × The **angle** of the **pillar** in a **vertical plane front view**
 - × the **form** of the **pillar straight** or **arc-form**
 - × **Angle** of the **windshield**
 - × **Height** of the **driver** in relation to the **dashboard**
 - × **Speed** of the **opposite car**

cc



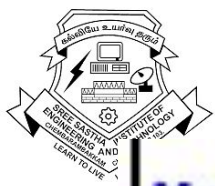
As cars get safer and stronger, our view of the road seems to be getting worse. Vehicle blind spots account for around 1% of all road accidents, and around 25 deaths a year.

So does being well-protected in a crash have to come at the expense of being able to see cyclists, pedestrians and other road users properly?



Small windows and a wide C pillar create a large blind spot in the 2009 Astra

- × View from the driver's seat
- × Today's cars are a lot safer in a crash than they were 20 years ago, but a common complaint with modern cars is that visibility has suffered as a result.
- × Windscreen and door pillars have become far bigger, while today's car stylists also seem to favour designs that restrict visibility.
- × It's not only the view forward that's suffering.
- × All-round visibility is generally worse.
- × This makes manoeuvring difficult, and it's also detrimental to your rear three-quarter view, which is crucial for changing lanes, pulling away from a standstill and emerging from acute junctions. **CC**
- ×



Methods to Improve Visibility

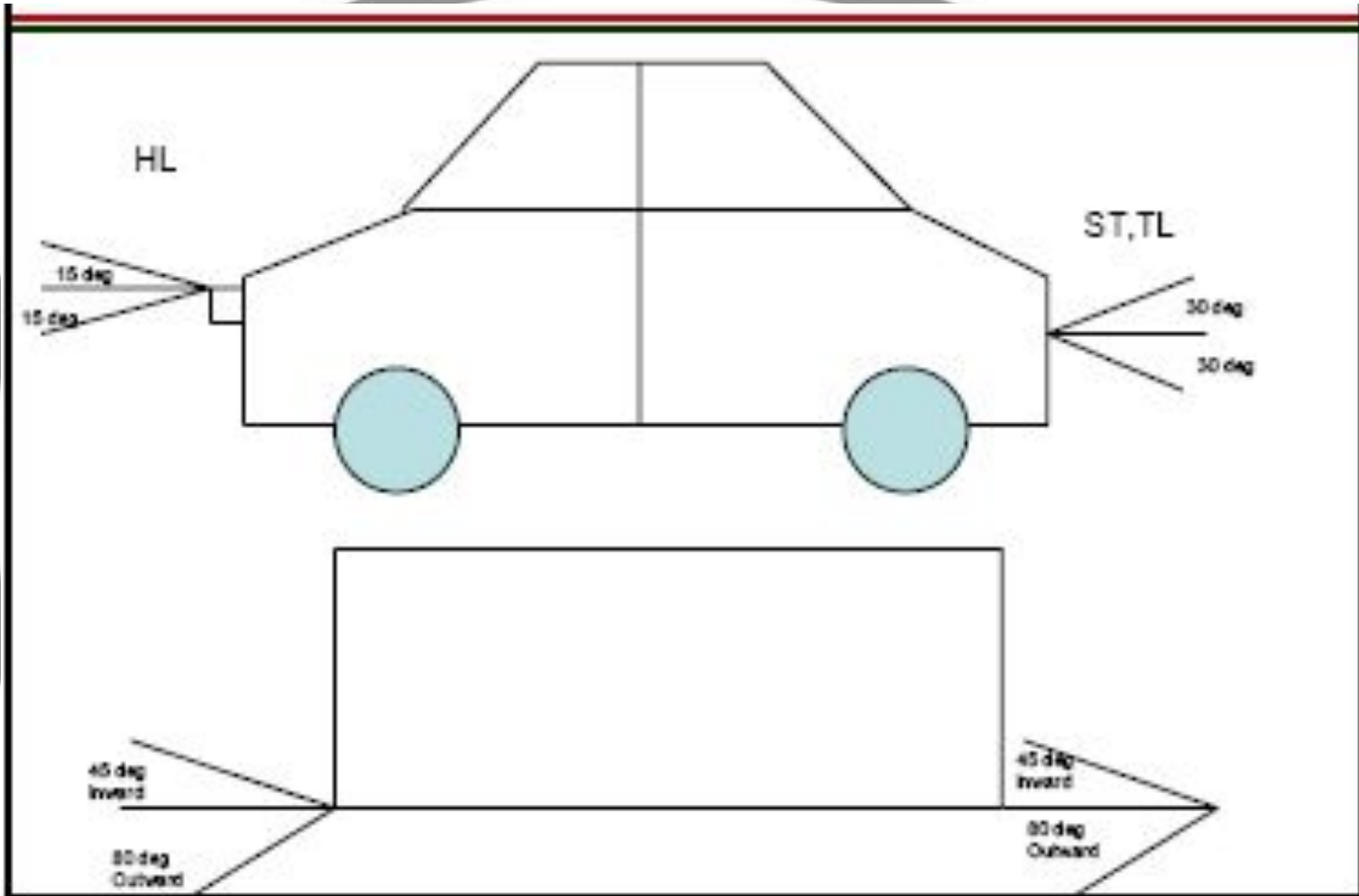
- Day Light – Color most important characteristic – **Bright Color**
- Glitters – make the car more Visible & Attractive – **Metallic paints are used**
- Lamps must be positioned at correct location – prevent Dazzling (HL – 15 deg & ST -30 deg)
- Lamps turn – 45 deg inward & 80 deg outward –illuminating the road.
- **Repeated Flasher type** – Direction indicator – better than Semaphore arm direction indicator (olden days)

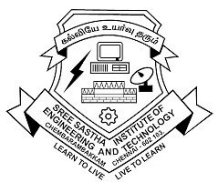
Methods to Improve Visibility

- **Semaphore arm direction indicator** – Olden days – RHS – not attractive for drivers in opp direction- no side indicators



- Low Positioning of Lights should be avoided – Following drivers
- HL, TL, SL – at higher level





Methods to Improve Visibility

- **Non Dazzle Rear View Mirror** – dark – Estimate the **distance of following vehicles** on dipped HL
- **Steerable Auxilary Head Lamps** : Sharp bends – inner side of road is invisible – **Coupling Device** b/w steering arms & HL – which turns HL in a direction – car is turning – **Ackermann effect**

Principle

- Inside Head Lamps is directed very well round the corner & outside one less – improves the road views

Measurement of Visibility:

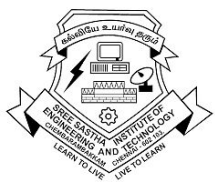
- Driver Position – Important – Eye Position
- Driver Eye – 2 inches apart & facing forward
- Driver Eye – line perpendicular to long axis of vehicle
- Driver Eye – Each eye is at a Vertical Height of $26 \frac{1}{2}$ inches above the point on the undeflected seat
- Driver Eye – 5 inches in front of Vertical tgt to the seat squab (backrest position of seat)
- Commercial Vehicles – Driver Eye position at same ht with 'C' as a correction factor for seat back angle
- Driver seat Adjusted – Effective Length $a+b = 36 \frac{1}{2}$ inches

Measurement of Driver Visibility:

- Direct Measurement – difficult
- Most Common Method – Two Projector lamp bulbs are placed in the eye position & visibility is measured by shadows of these bulbs on a screen

Forward Vision :

- Electric lamps –specified eye position – vehicle is placed facing a semi circular visibility screen
- Mid point of Driver's eye lies on the cylindrical axis of the screen
- Visible Areas – outline by shadows of the wind screen pillars, windscreen wiper sectors on the screen when lamp is on.



Rear End Vision :

- Light from lamp is reflected from the mirror & falls on two plane screens placed l1el to each other at a known distance apart –behind the eyes
- Illuminated area on each screens – ground plan of rear end vision
- CV's – External mirror

Visibility test

Which cars allow you a perfect view? and which are a pain to park?

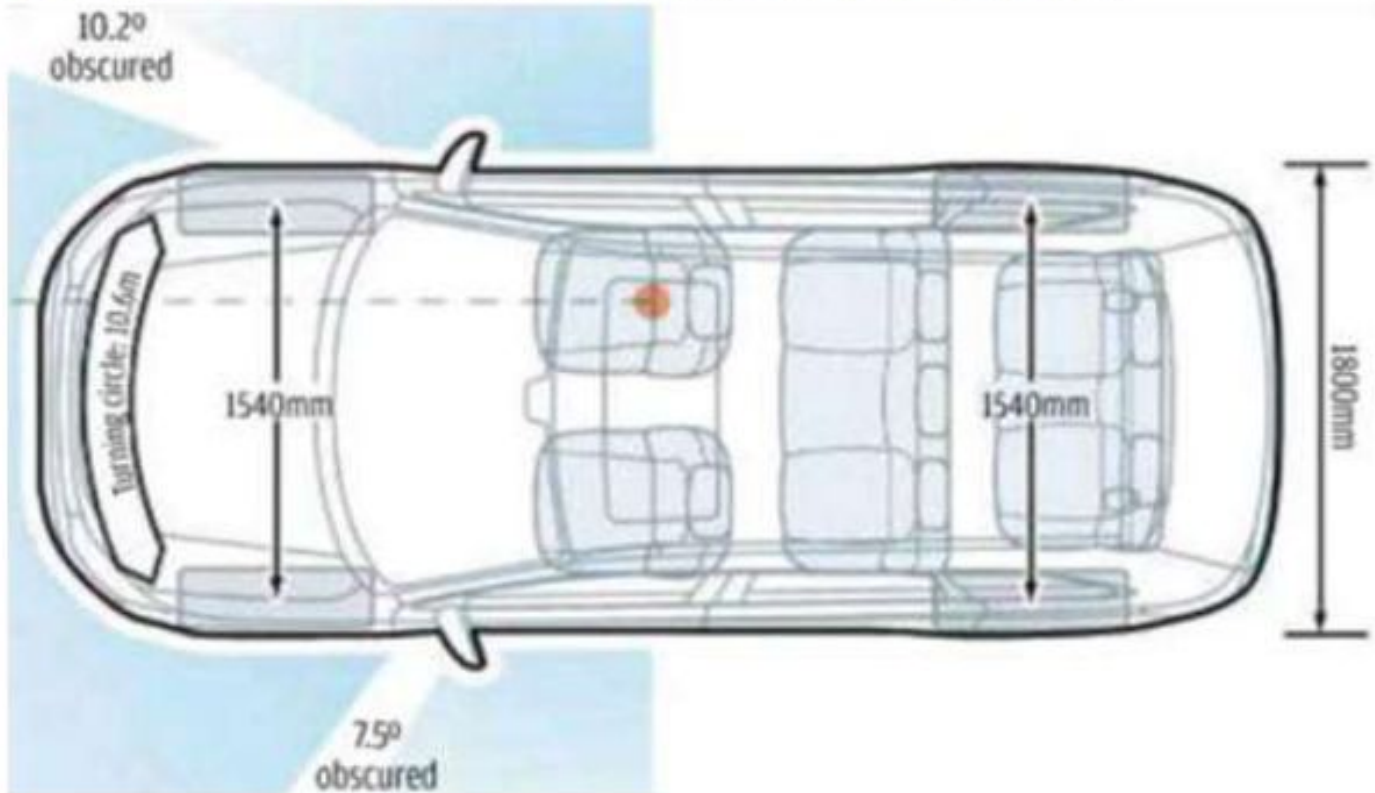
visibility testing of every vehicle is done from the driver's seat using hi-tech equipment.

Every car that passes test Lab is assessed in a specially designed visibility rig, using lasers, digital cameras and sophisticated computer software to rate visibility from the driver's eye position.



- × By fixing a camera at a typical driver's head height, using a fixture in the front seat, we can pan a full 360 degrees around the car's interior, logging how much of the view is clear window and how much is obstructive – including the pillars, roof and headrests.
- × a 'line of sight' test is also carried out to work out whether you can see any low bollards, pets or other hazards while parking – this is affectionately known as the 'sausage dog' test.
- × Aspects such as the view in the mirrors, the size of the swept area of the windscreen, headlight beam pattern, reversing sensors and windscreen reflections all go towards our overall visibility score. cc

VISIBILITY TEST- MITSUBISHI'S OUTLANDER



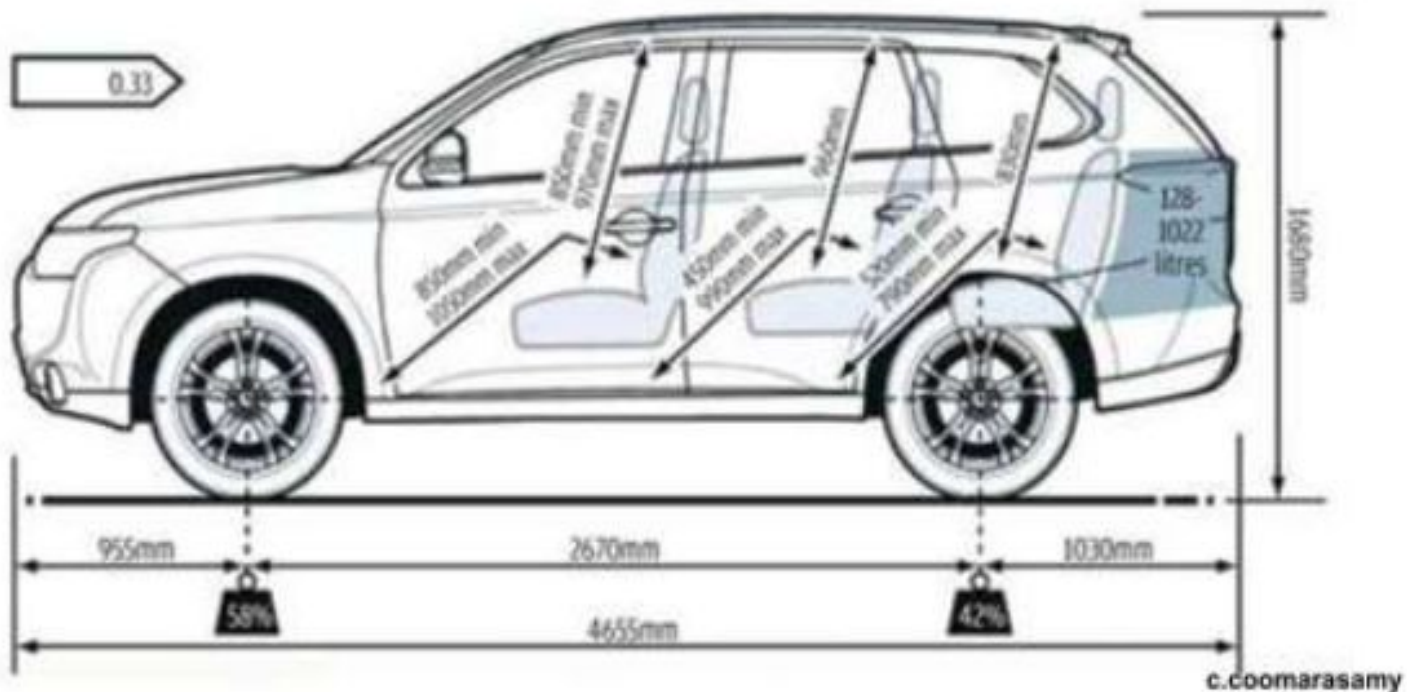
Front: **Driver's pillar** is the main issue because **the cabin is tighter than the class norm**. Otherwise, **visibility is good**.

Headlights: Lateral spread of light is good on standard xenons, which also self-level when towing.

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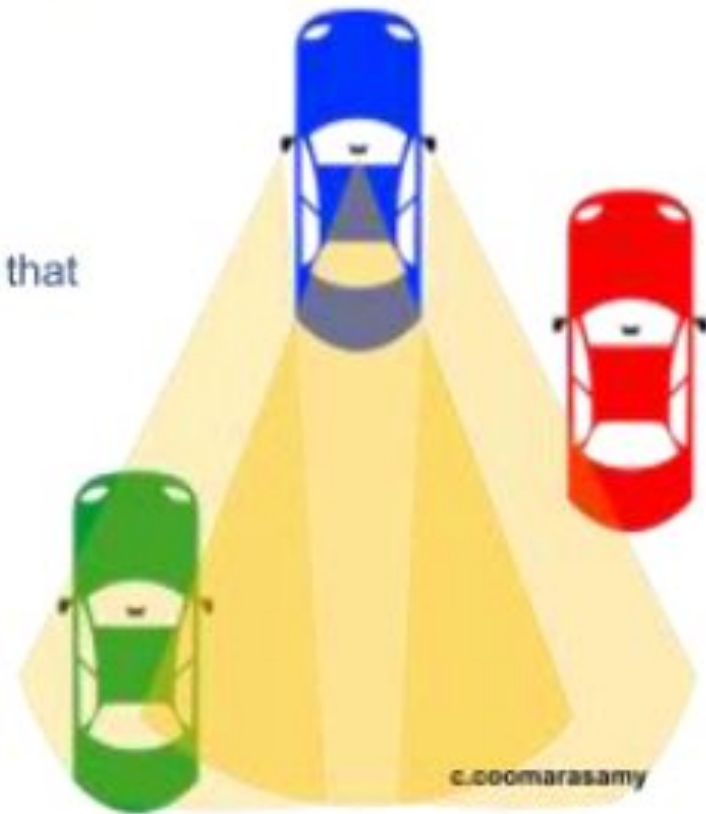
VISIBILITY-BLIND SPOTS

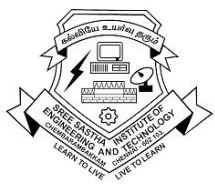
- × A **blind spot** in a vehicle is **an area around** the vehicle that **cannot be directly observed** by the **driver** while at the controls, under existing circumstances.
- × **Blind spots** exist in a wide range of vehicles: cars, trucks, motorboats and aircraft.



VISIBILITY-BLIND SPOTS

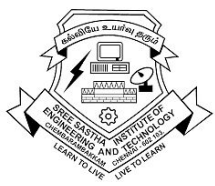
- × **Blind spots** may occur in the front of the driver when the A-pillar (also called the windshield pillar), side-view mirror, and interior rear-view mirror block a driver's view of the road.
- × Behind the driver, there are **additional pillars**, headrests, passengers, and cargo, that **may reduce visibility**.
- × Motor vehicles
- × The **blue car's** driver sees the **green car** through his mirrors **but cannot see** the **red car** without turning to check his **blind spot**.





CAR BODY TERMINOLOGY

- **BACK LIGHT** : Central Window in the Rear Panel of Saloon Body
- **BODY SILL** : Panel directly below the bottom of the doors
- **Bonnet** : Metal Cover the Engine Compartment
- **Boot** : Luggage Compartment – Spare Wheel & Fuel Tank
- **Bottom Side** – Base Frame Member –along the full length of car body
- **Bulkhead** – Transverse support or assembly in body structure



CAR BODY TERMINOLOGY

Near Side – LHS of the vehicle when viewed from driver seat

Offside – RHS of the vehicle when viewed from driver seat

Pillar – Vertical Support of a body frame

Pillar Face – Front of the pillar visible when the door is opened

Quarter Light – Window directly above the Quarter panel

Quarter Panel - Side Panel extending from the door to the rear end of the body including the rear wing

SAFETY DESIGN OF VEHICLE

- **Vehicle Design** – Ensure Max Safety of the Driver, Passengers & other Road Users
- **Vehicle Design** – not to withstand **Collision** but reduce its effect
- **Collision** – Obstacle or another Vehicle at high speed
- **Vehicle Stylists** – Avoid Sharp Ornaments & edges and also projecting elements such as door handles, mirrors.

DESIGN OF BODY FOR SAFETY

KE destroyed during collision

$$E = (M - \Delta M) V^2 / 2$$

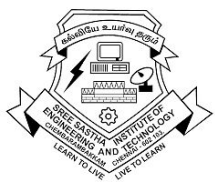
M = Total Mass of Vehicle

ΔM = Movable mass

V = Velocity

KE destroyed – Absorbed as work done on materials by elastic deformation

$$(M - \Delta M) V^2 / 2 = \int P \, ds = (S^2 / (2E)) * A * l$$



DESIGN OF BODY FOR SAFETY

P = Force Generated During Collision – Inversely proportional to the distance travelled by vehicle

s = distance travelled during collision

S = Local Stress in the material

E = Young's Modulus of Material

A = Cross Sectional Area

l = deformation

DESIGN OF BODY FOR SAFETY

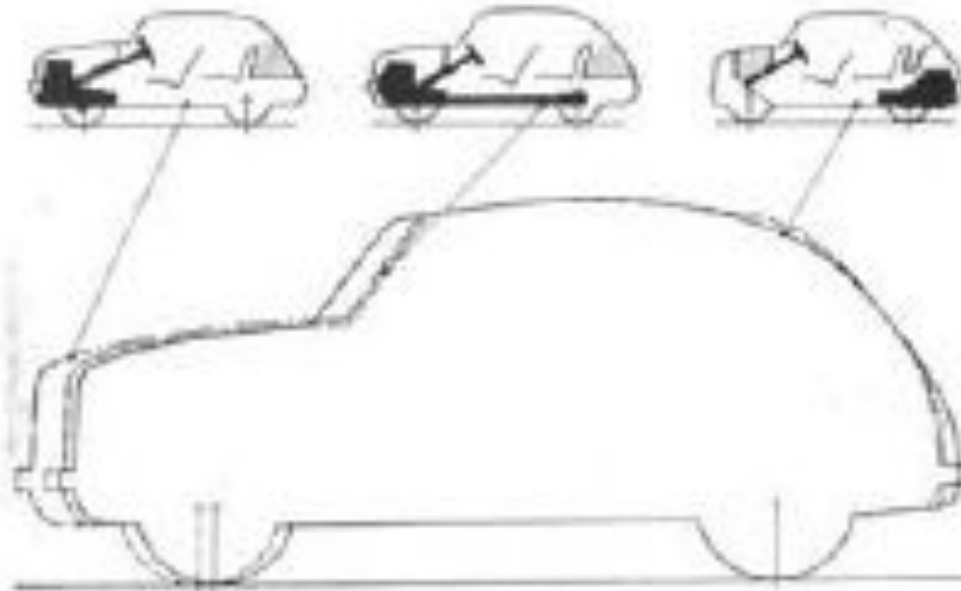
- **Bumper** – First part – Collision
- distance travelled by vehicle after Collision – Very important
- **More Distance** – Min Injury to the passenger
- Bumper & other Collision Material – **Light alloys or Al or Rubber**

DESIGN OF BODY FOR SAFETY

Rear Engine Vehicle Has a Greater Distance for the front structure to crumple



DESIGN OF BODY FOR SAFETY



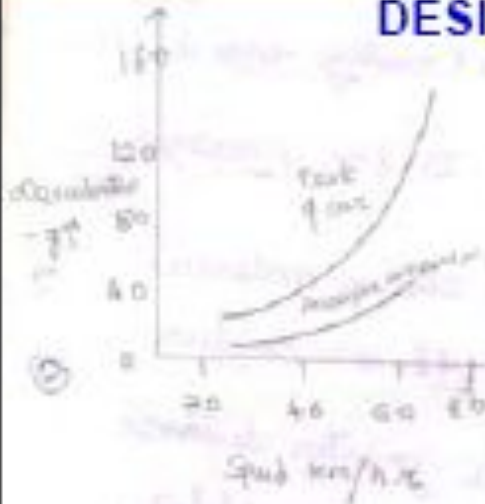
Crumple Zone

FMFD

FMRD

RMRD

DESIGN OF BODY FOR SAFETY



Deceleration of the Front part & Passenger Compartment on impact with a Stationary obstacle

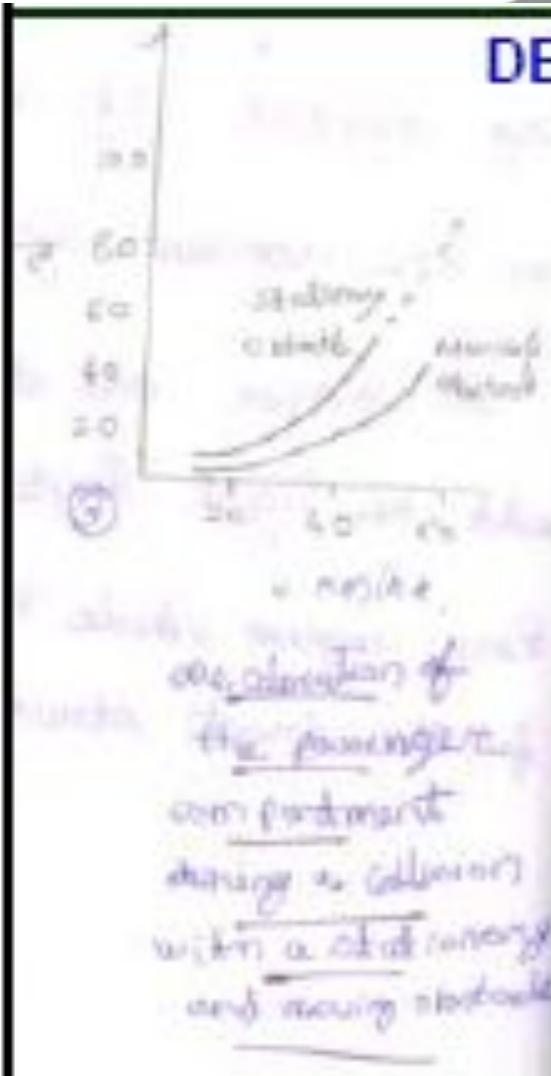
- 20 % of the Max Retardation is felt in the passenger compartment
- Peak Value – 0.05 sec –
- Human response slower

Deceleration of the front part & passenger compartment on impact with stationary obstacle

DESIGN OF BODY FOR SAFETY

Deceleration of the Passenger Compartment on impact with a Stationary & Moving obstacle

- Deceleration are less for Moving Obstacle
- Larger distance over which the force travels before the vehicle coming to rest.

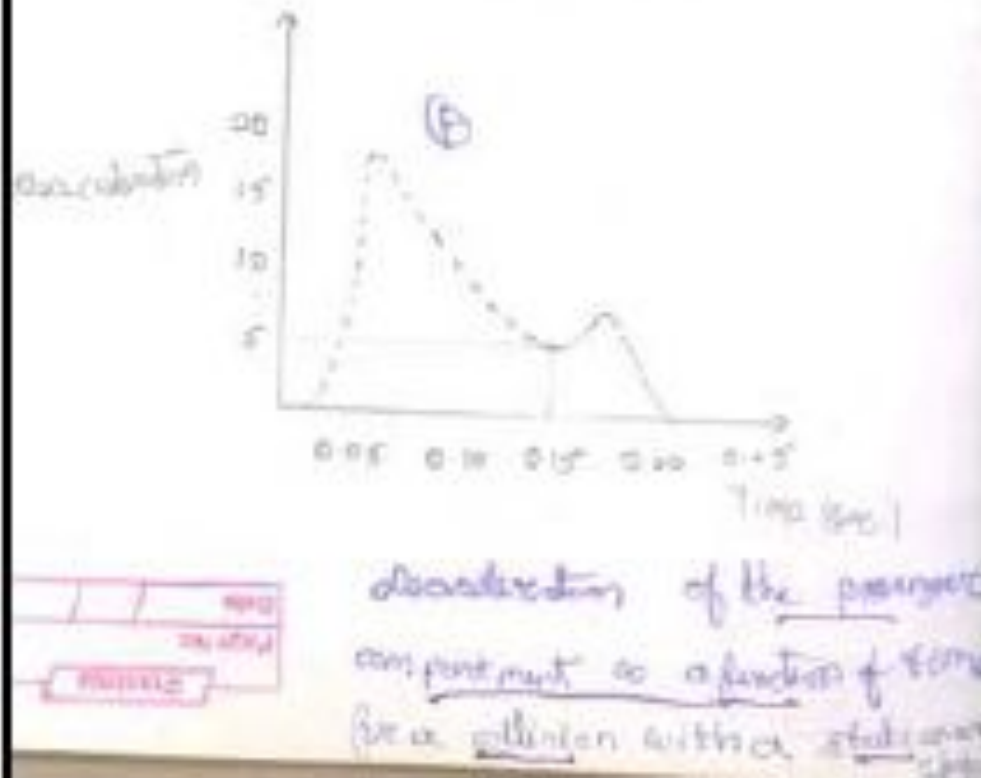


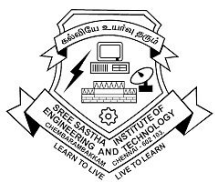
DESIGN OF BODY FOR SAFETY

Deceleration of the Passenger Compartment as a function of time for a collision with a stationary obstacle

- Human Response time – slower – doesn't allow him to prepare for an impact within a short duration

- Safety features must be incorporated in a vehicle





DESIGN OF BODY FOR SAFETY

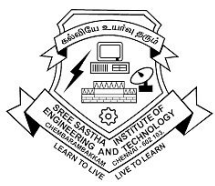
- Long Energy Absorbing Distances should be provided in vehicle design
- Parts of the Front structure used should have lower stiffness than the central section or the passenger compartment of the vehicle.

SAFETY FEATURES

- **Bumper Design –**

- Bumper should be Designed to absorb more Energy - Crash Test
- Big Shock Absorbers may be Used Behind the bumpers
- Semicircular Shape – Avoids Direct Collision & Tilt of the Vehicle





SAFETY FEATURES

- **Bumper Design –**

- **Height of the Bumper** should be such that if it hits the **pedestrian below the Knee**, he will fall on the Vehicle – Less Danger

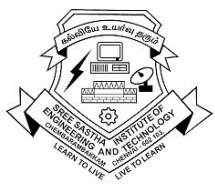
- **Ignition Switch**

- Connected with Door Lock that ignition can be switched on, Only when all four doors are perfectly locked.

- **Air Bags & Safety Belts**

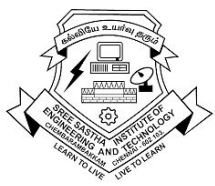
- **Herlamic Flash or Horn (peep Sound) :**

- For Every 1 min – if the driver doesn't put off then ignition will be automatically switched off



SAFETY FEATURES

- Collapsible or Telescopic Steering Column
- Wind Screen- Heat Toughened Glass (HTG) or Zone Toughened Glass (ZTG)
- HTG – Glass will be crumble in to short pieces – No sharp edges only blunt edges
- ZTG – It may cracked big size but doesn't fall on the road

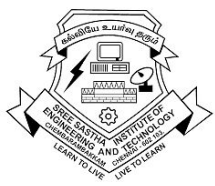


SAFETY DESIGN

- **Preventive Design (Min Chances for Accident)**
- Largest Possible Glass Area – min Blind spots – Better Visibility
- IP panel – Driver must read all meters & see all indicators
- Easy access to Controls
- Driver Seat – Comfortable & Adjustable
- Vehicle Noise must be min
- Steering & Suspension System – Vehicle Handling
- Brakes must not Skid
- ABS, TCS, ESP

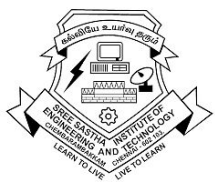
SAFETY DESIGN

- **Design for Min Injury**
- Rigid Body – Transmit entire Impact Energy to Occupants
- Weak Body – Crumble on to the occupants
- Side Impact – Doors are Strengthened by steel bars
- Overturning or Roll – Stiff roof or anti roll bars
- Fuel Tank Location
- Seat Belts ,Air Bags, Collapsible steering column



PASSENGER CAR CONSTRUCTION

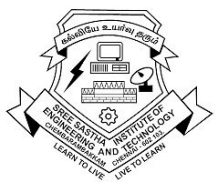
- Frt & Rear Bulk Heads – Torsional Stability
- Roof – Stable Structure – Curved Shape - Prevents Misalignment
- Floor Complete Panel – Frt to Rear – Ribs – to Prevent Buckling
- Floor with sill, wheel arch , cross member & heel board form strongest part of body
- Rear Bulk Head with seat squab – stable structure



SAFETY

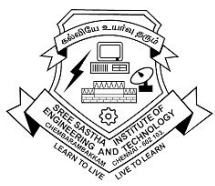
- × Active and passive safety
- × The terms "active" and "passive" are simple but important terms in the world of automotive safety.
- × "Active safety" is used to refer to technology assisting in the prevention of a crash and "passive safety" to components of the vehicle (primarily airbags, seatbelts and the physical structure of the vehicle) that **help to protect occupants** during **a crash.**

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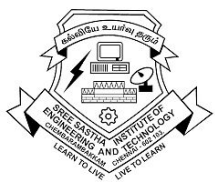
ACTIVE SYSTEMS

- × **Active safety systems** are operating all the time i.e. they are not waiting for an accident to occur.
- × **Antilock brakes** – Electronically controlled system to prevent the wheels from locking and skidding when the brakes are applied. This helps the driver maintain control when braking.
- × **Aerodynamic stability** – A stable car is less likely to go out of control
- × **Dual circuit brakes** – Standard on all modern cars, if one brake pipe bursts, the brakes will still work on at least two wheels.
- × **Comfortable driving position** – The driver is more likely to be able to react to potential trouble.
- × **Safety glass** – Toughened glass shatters on impact into small road granules which do not cause cuts, but vision is impaired. Modern laminated glass resists heavy impacts without shattering and vision remains good
- × **Good ventilation** – Helps to keep the driver awake and alert.
- × **Efficient bad weather equipment** – Good lights and good windscreen wipers, to name just two parts, ensure the driver can see and be seen.



PASSIVE SAFETY SYSTEMS

- × **Passive safety systems** start operating in the event of an accident.
- × **Air Bags** – In the event of an accident these bags 'explode' onto position to cushion the driver and passenger.
- × **Antiburst door locks** – These door locks prevent the doors from flying open.
- × **Collapsible steering column** – used to try prevent chest injuries to the driver, the steering column collapses and is pulled down away from the driver in the event of a front end collision.
- × **Crumple zones** – When an impact occurs, the movement energy has to be dispersed. If this is passed through to the passengers, then serious injury will result. Crumple zones absorb as much of the energy as possible, reducing the risk to the occupants.
- × **Padded steering wheel** – helps to reduce injury to the drivers chest.
- × **Rollover cage** – In the event of the vehicle rolling over, a cage prevents the cabin from collapsing.
- × **Seat belt tensioners** – Pull the seat belt tighter at the instant of impact.
- × **Side impact bars** – Bars in the door which strengthen the side of the vehicle



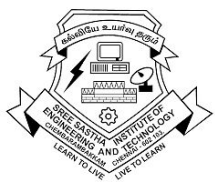
SAFETY

- × Crash avoidance
- × Crash avoidance systems and devices help the driver — and, increasingly, help the vehicle itself — to avoid a collision.

This category includes:

- × The vehicle's headlamps, reflectors, and other lights and signals
- × The vehicle's mirrors
- × The vehicle's brakes, steering, and suspension systems

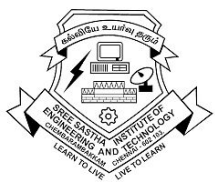
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SAFETY

- × **Safety equipments for cars:**
- × **Bumper design:** The bumper should be designed to absorb more energy.
- × **Ignition switch** should be connected with door lock that ignition can be switched ,only when all four doors are perfectly locked.
- × **Airbag** and **Safety bags** have to be used.
- × **Heelomatic flash or Horn.**
- × **Collapsible steering.**
- × **Heat toughened glass.**

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DRIVER ASSISTANCE

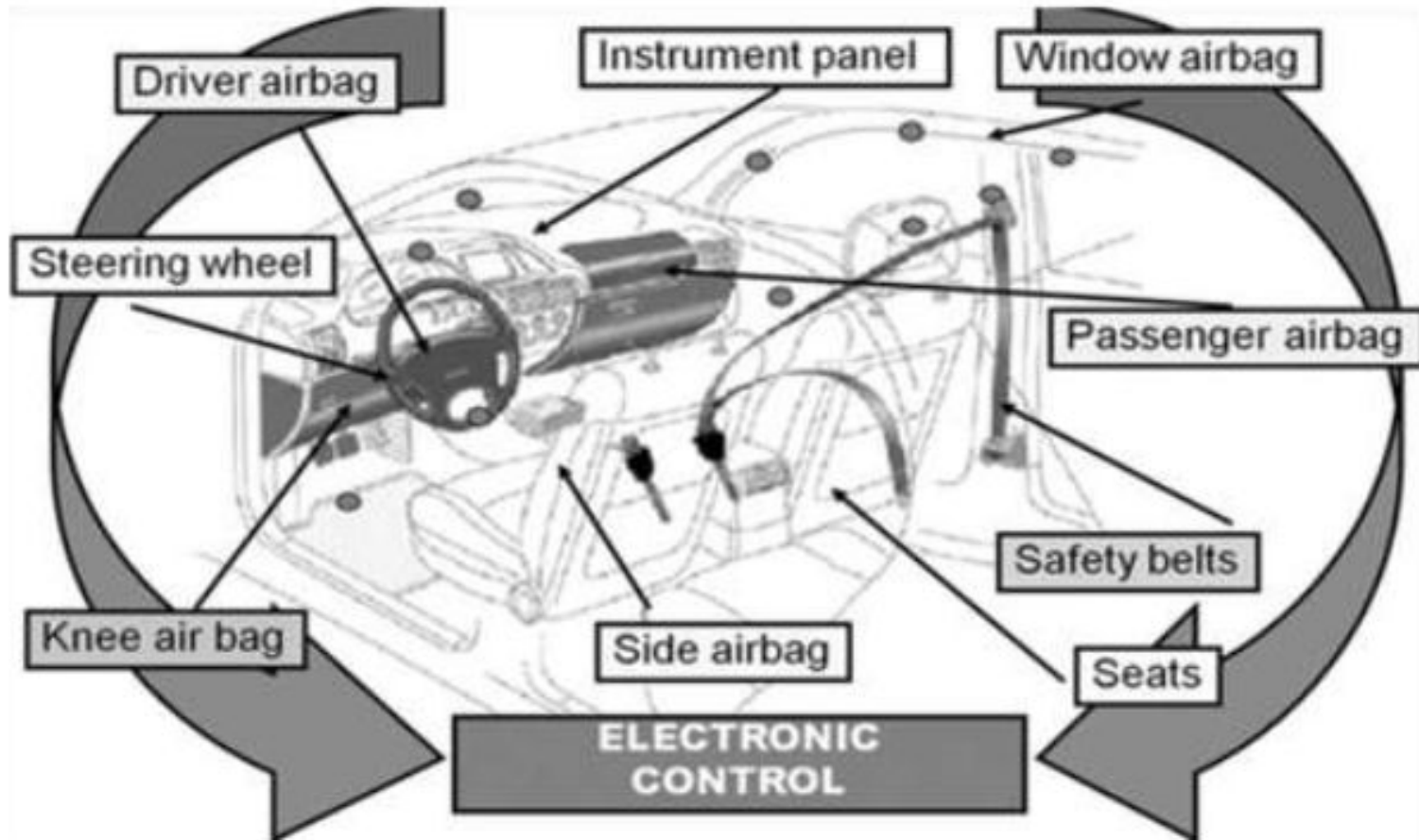
- × A subset of crash avoidance is **driver assistance systems**, which help the driver to detect obstacles and to control the vehicle.

Driver assistance systems include:

- × **Automatic Braking** systems to prevent or reduce the severity of collision.
- × **Infrared night vision** systems to increase seeing distance beyond headlamp range
- × **Adaptive headlamps** control the direction and range of the headlight beams to light the driver's way through curves and maximize seeing distance without partially blinding other drivers
- × **Reverse backup sensors**, which alert drivers to difficult-to-see objects in their path when reversing
- × **Backup camera**

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CAR PASSIVE SYSTEM



CRASHWORTHINESS

- × **Crashworthy** systems and devices **prevent or reduce** the **severity of injuries** when **a crash is imminent** or **actually happening**.

Much research is carried out using **anthropomorphic crash test dummies**.



- × **Seatbelts** limit the forward motion of an occupant, stretch to absorb energy, to lengthen the time of the occupant's deceleration in a crash, **reducing the loading on the occupants body.**



They **prevent occupants being ejected from the vehicle** and **ensure that they are in the correct position** for the **operation of the airbags**.

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CRASHWORTHINESS

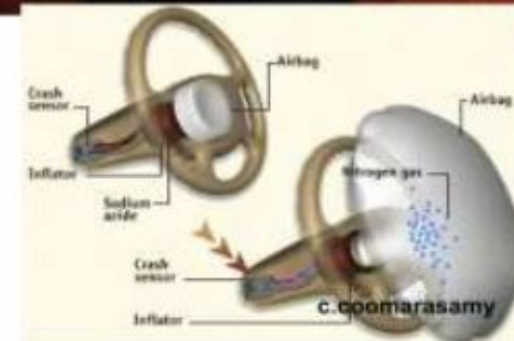
Airbags inflate to cushion the impact of a vehicle occupant with various parts of the vehicle's interior. The most important being **the prevention of direct impact** of the driver's head with **the steering wheel and door pillar**.



Drivers Side Air Bag



Ferrari F430 steering wheel with airbag



Air Bag in Steering Column

Exploded view of a driver air-bag

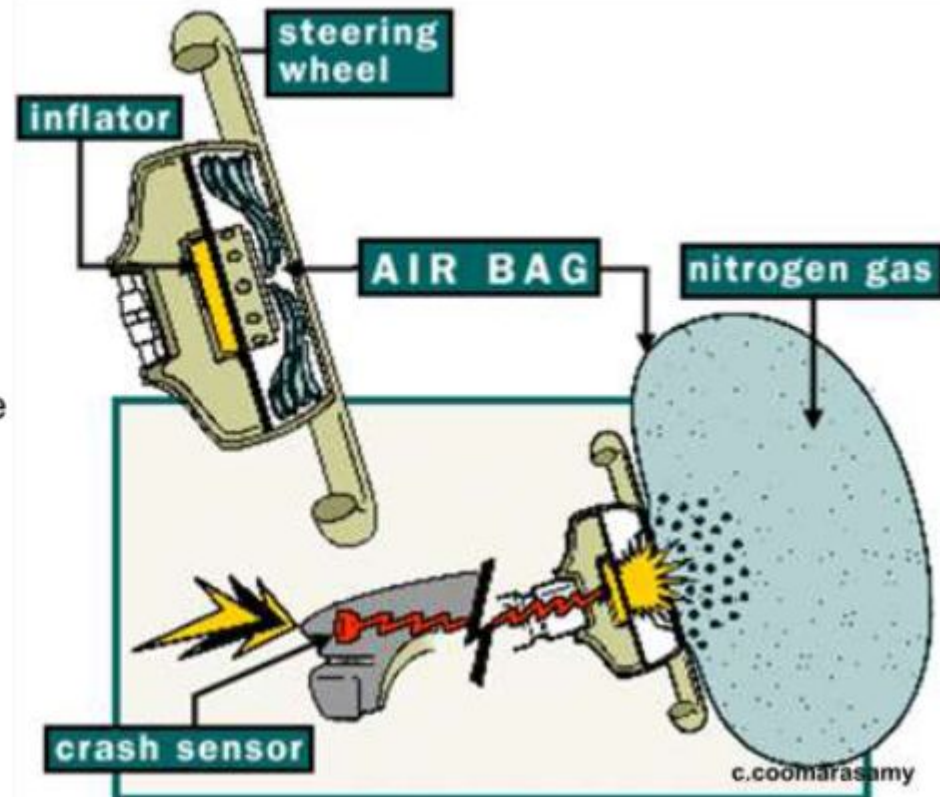


CRASHWORTHINESS

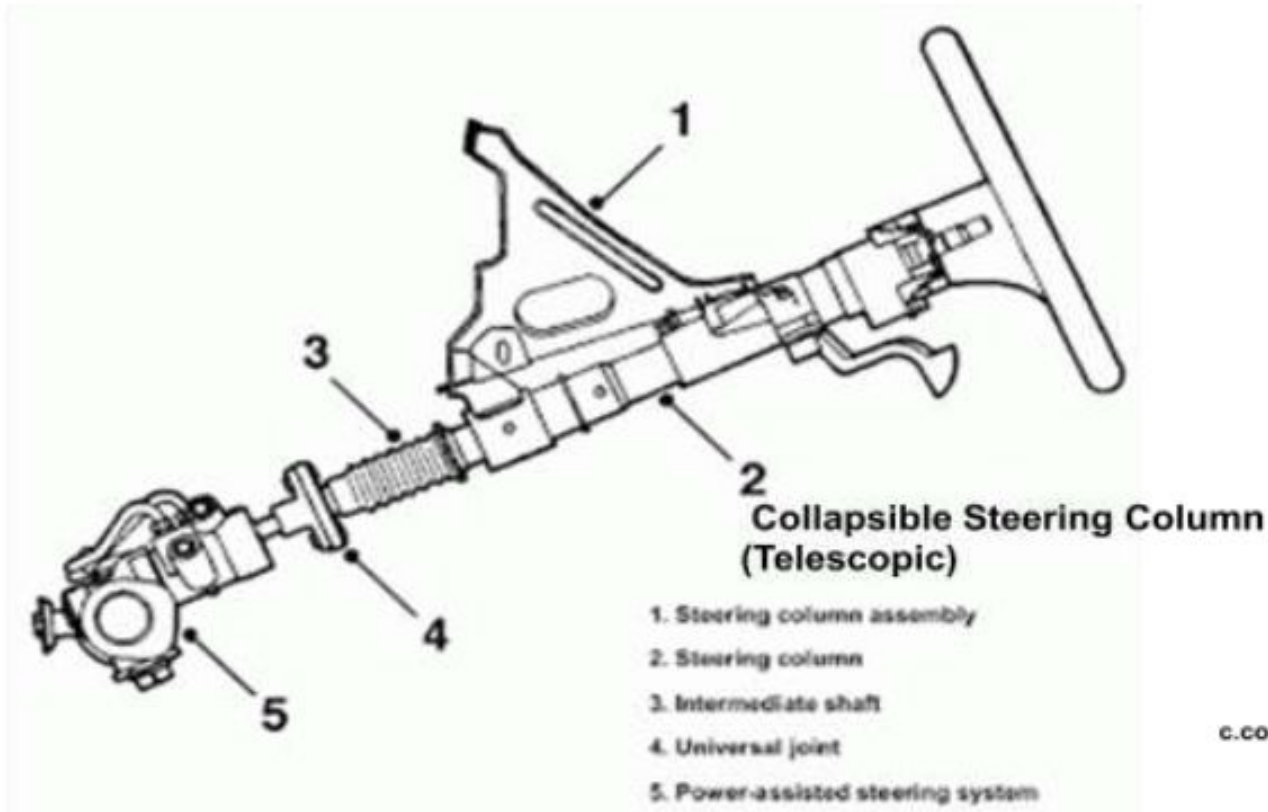
Airbags

An **airbag** is a vehicle safety device.

It is an occupant restraint consisting of a flexible envelope designed to inflate rapidly in an automobile collision, to **prevent vehicle occupants** from **striking interior objects** such as the **steering wheel** or **window**.

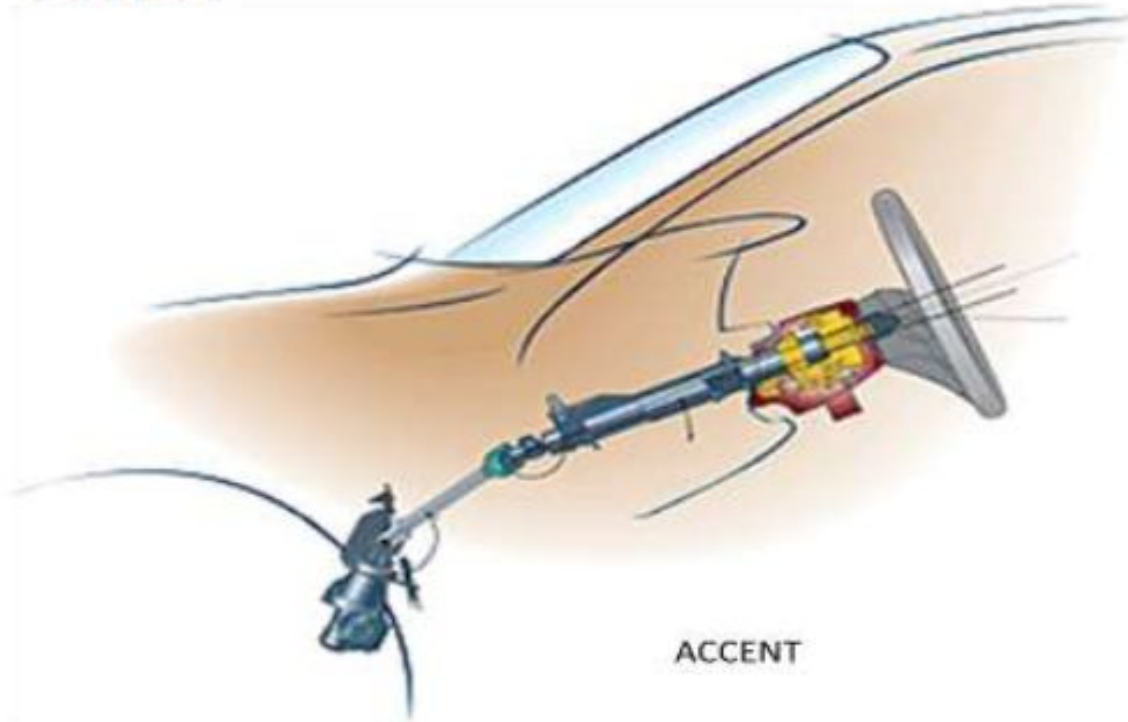


SAFETY



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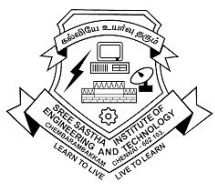
SAFETY



The steering column is fully collapsible and minimizes risk of chest injuries in the event of a frontal impact .

Safety
Collapsible Steering Column

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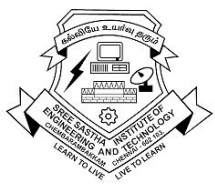


Laminated windshields remain in one piece when impacted, preventing penetration of unbelted occupants' heads and maintaining a minimal but adequate transparency for control of the car immediately following a collision. It is also a bonded structural part of the safety cell.

Tempered glass side and rear windows break into granules with minimally sharp edges, rather than splintering into jagged fragments as ordinary glass does.

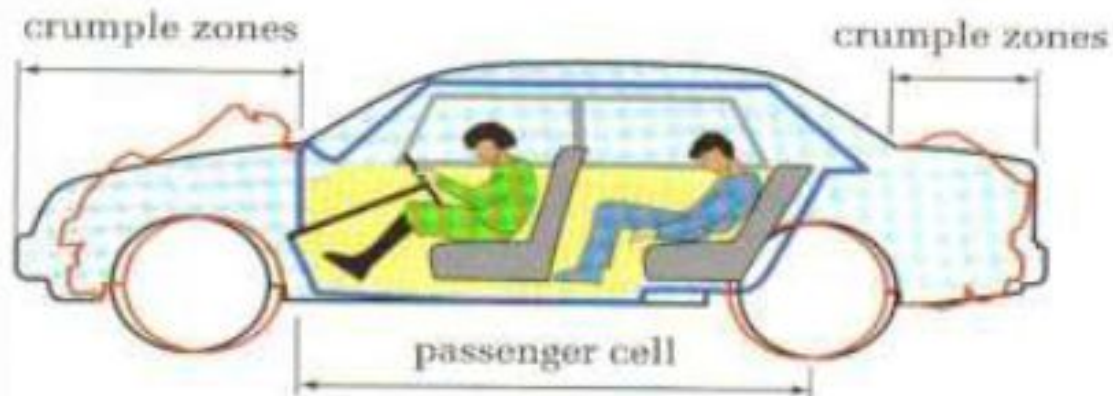
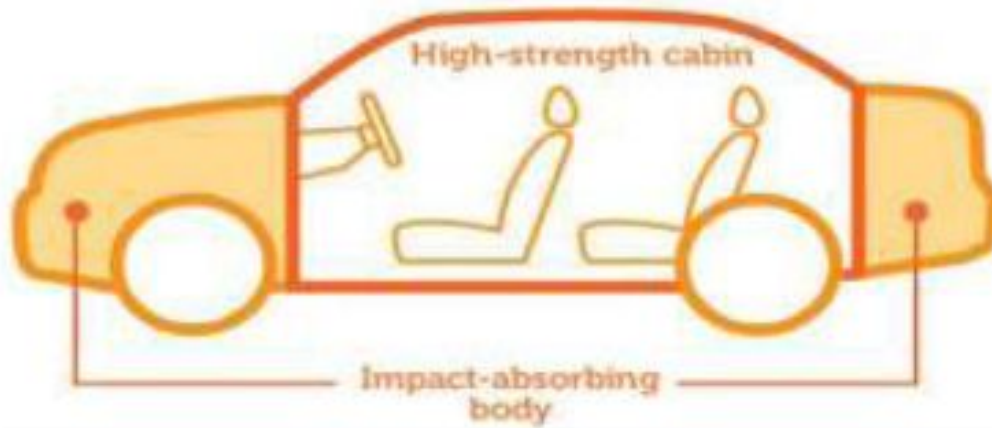
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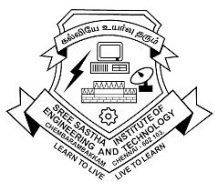




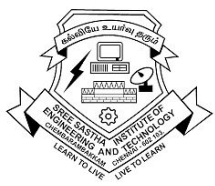
- ✖ Crumple zones absorb and dissipate the force of a collision, displacing and diverting it away from the passenger compartment and reducing the deceleration impact force on the vehicle occupants.
- ✖ Vehicles will include a front, rear and maybe side crumple zones (like Volvo SIPS) too.
- ✖ Safety Cell - the passenger compartment is reinforced with high strength materials, at places subject high loads in a crash, in order to maintain a survival space for the vehicle occupants.
- ✖ Side impact protection beams, also called anti-intrusion bars.
- ✖ Collapsible universally jointed steering columns, along with steering wheel airbag.
- ✖ The steering system is mounted behind the front axle - behind and protected by, the front crumple zone. This reduces the risk and severity of driver impact or even impalement on the column in a frontal crash.

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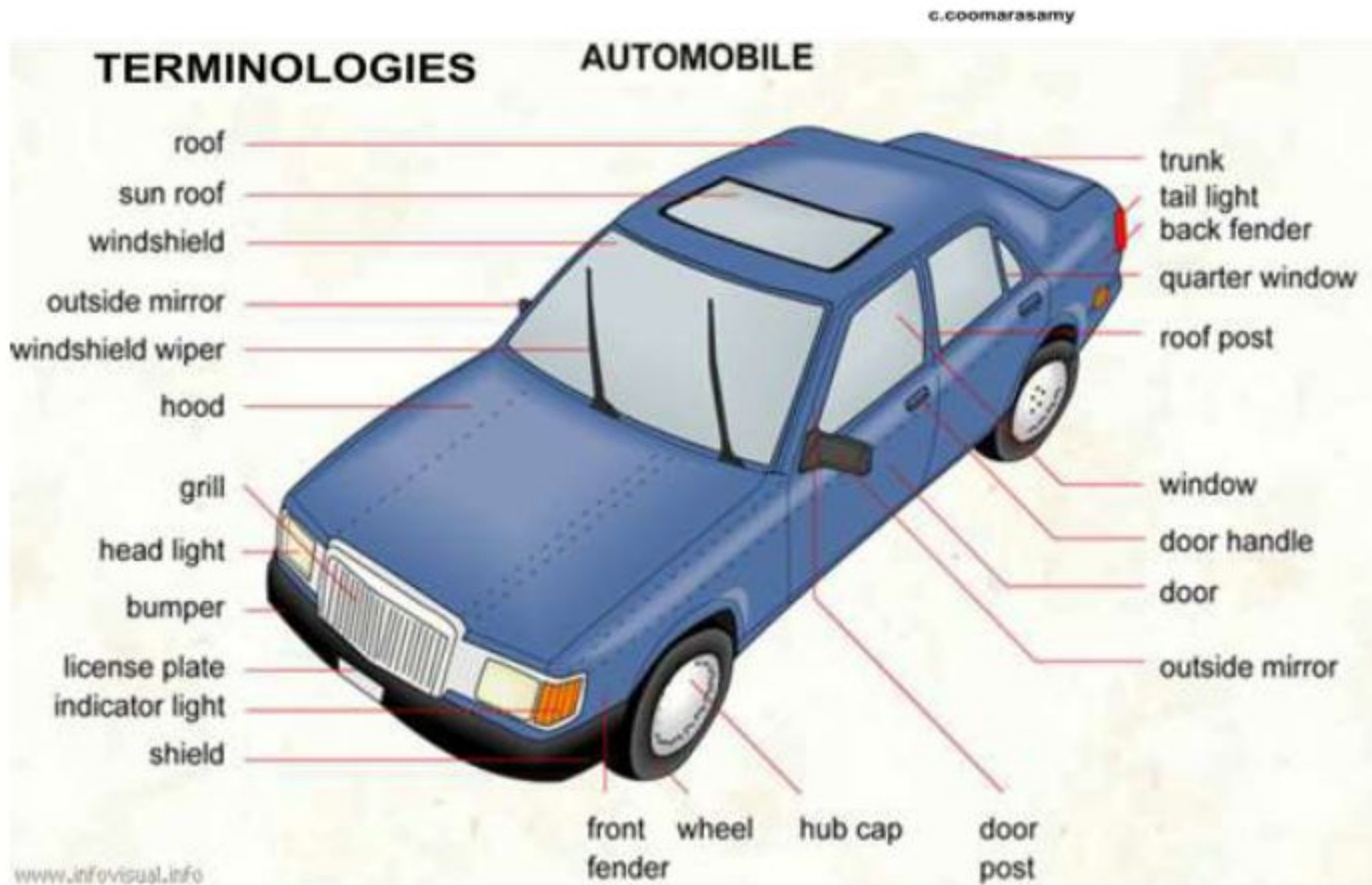


- ✗ Pedestrian protection systems.
- ✗ Padding of the instrument panel and other interior parts, on the vehicle in areas likely to be struck by the occupants during a crash, and the careful placement of mounting brackets away from those areas.
- ✗ Cargo barriers are sometimes fitted to provide a physical barrier between passenger and cargo compartments in vehicles such as SUVs, station wagons and vans.
- ✗ These help prevent injuries caused by occupants being struck by unsecured cargo.
- ✗ They can also help prevent collapse of the roof in the event of a vehicle rollover.



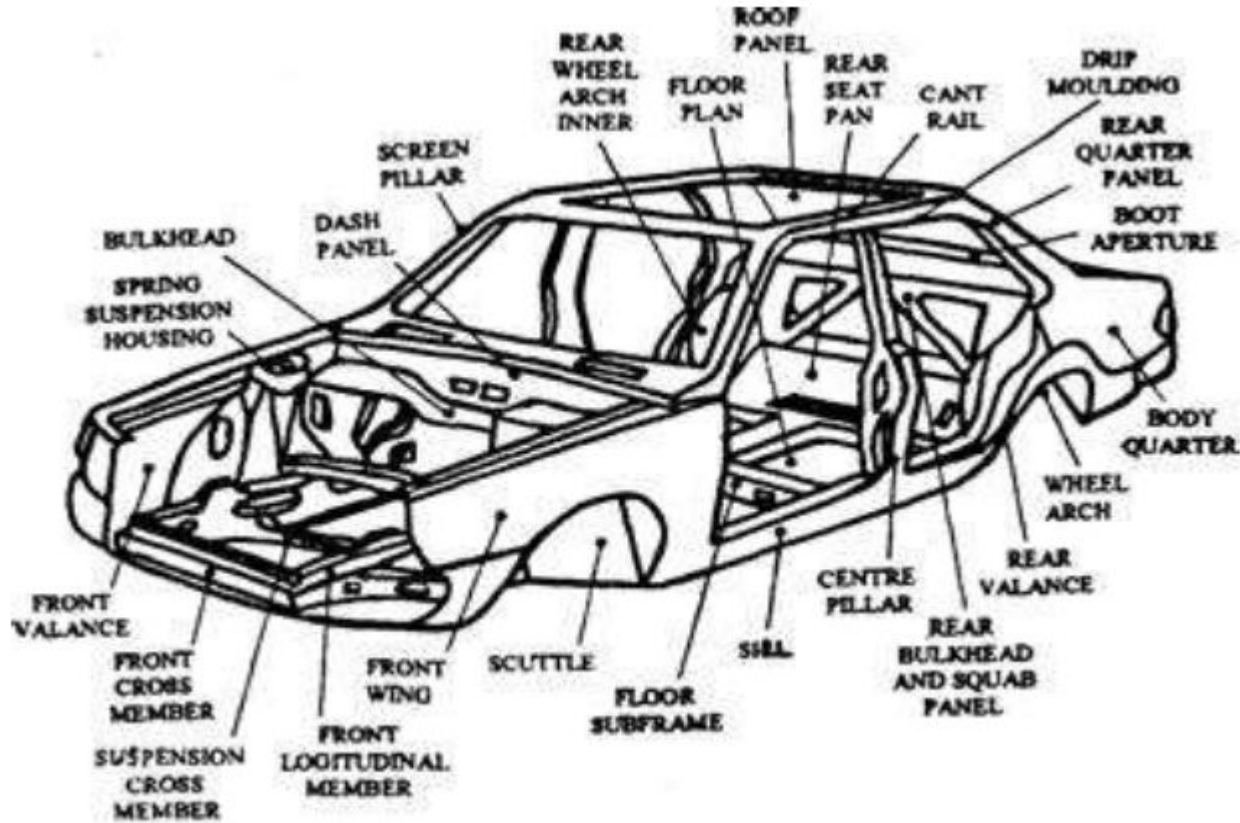
TERMINOLOGY

- × **Chassis** – The basic frame for a motor vehicle
- × **A Post** - The post on which the front door hinges are fixed.
- × **Body mounting** – Fittings for mounting the body to the chassis for older type cars or heavier vehicles.
- × **Composite construction** - The chassis and body of the vehicle are built as two separate units,
- × **Integral construction** – Most modern light vehicles use this method, also called mono or unity construction. The body and chassis are combined.
- × **Car derived van** – A van which is based on a similar car.
- × **Body panels** – Wings, bonnet and door for example.
- × **BC Post** – The centre post, the 'B' post has the front door striker plate and the 'C' has the hinges for the rear doors. Only appropriate to four/five door vehicles.
- × **D Post** – The rear post on which the rear door striker is fitted. Front door striker if a two/three door vehicle.



All vehicles are made up of separate systems and components, they have their own purpose and operation, however, all of these systems are brought together to give us the modern motor vehicle.



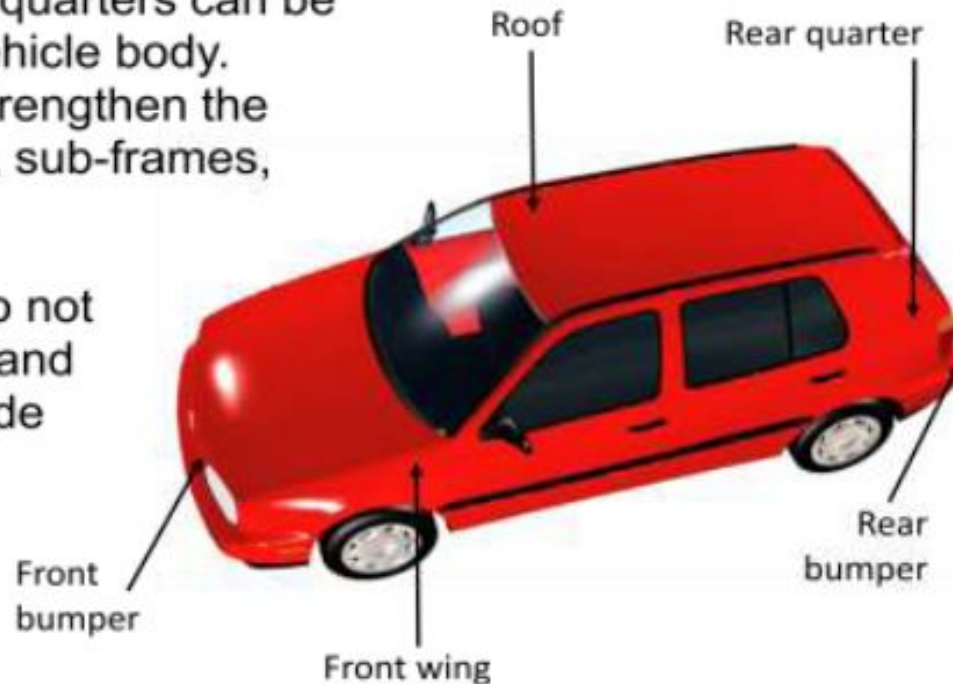


All vehicle component locations are identified by sitting in the driving seat. These are front, rear, left and right. In the diagram below, the left front wing can easily be identified.

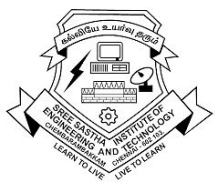
The roof, front wings and rear quarters can be used to help strengthen the vehicle body. Other parts can also help to strengthen the vehicle body e.g. glass, doors, sub-frames, chassis and floor-pan.

On convertible vehicles that do not have a rigid roof the floor pan and centre tunnel are normally made stronger and stiffer.

The front and rear bumpers offer some protection in low speed front or rear impacts.





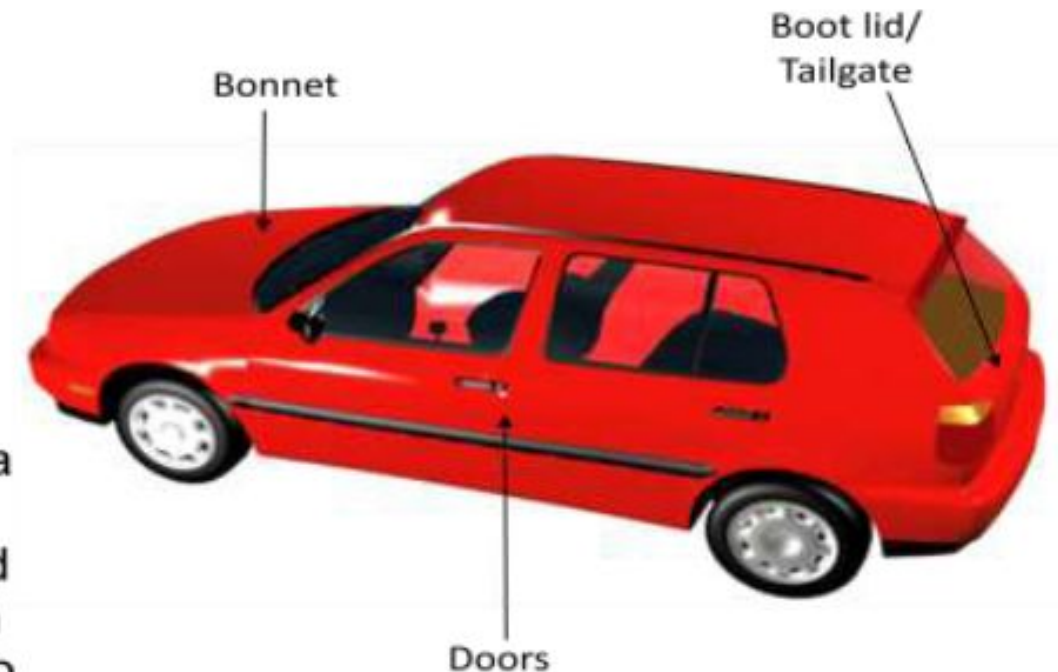


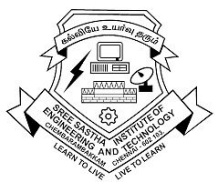
- ✕ Body Panels & Lighting include:
- ✕ Auxiliary Lights/Parts – Spotlight/Parts
- ✕ Door Mirrors
- ✕ Lights – Rearlight, Indicator, License Plate Light, Rear Fog Light, Reverse Light, Stop Lights
- ✕ Vehicle Rear – Bonnet, Bumper, Panelling, Wing
- ✕ **Body Panels** – Front Fairing, Mudguard, Rear-End Cowling, Wing
- ✕ Headlight & Bulbs
- ✕ Passenger Cabin – Auxiliary Stop Light, Doors, Mirrors
- ✕ Vehicle Front – Bonnet, Bumper, Fog Light, Headlight

The bonnet is a hinged cover for the engine compartment. It can be hinged to open toward the windscreen toward the front of the vehicle, or in some cases toward either wing.

The **boot lid** is a hinged cover over the boot. The boot is used as an area to store luggage or other items.

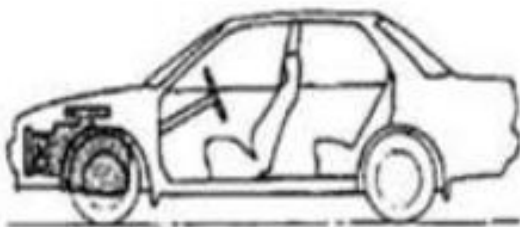
The doors are used as a means for the vehicle passengers to enter and leave the vehicle. When closed, the doors help to strengthen the vehicle.



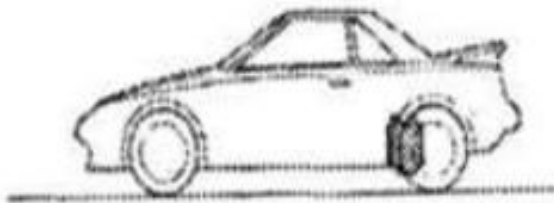


- × Engine position:
- × Front engine
- × The large mass of an engine at the front of the car gives the driver protection in the event of a head on collision.
- × Engine cooling is simpler to arrange.
- × In addition the cornering ability of a vehicle is normally better if the weight is concentrated at the front.
- × Rear engine
- × It increases the load on the rear driving wheels, giving them better grip of the road.
- × Most rear-engine layouts have been confined to comparatively small cars, because the heavy engine at the rear has an adverse effect on the 'handling' of the car by making it 'tail-heavy'.
- × Also it takes up good deal of space that would be used on a front-engine car for carrying luggage.
- × Most of the space vacated by the engine at the front end can be used for luggage, but this space is usually less than that available at the rear.

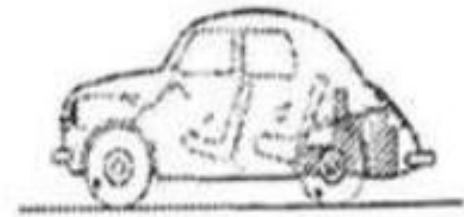
- × Central and mid-engine
- × These engine situations generally apply to sports cars because the engine sitting gives a load distribution that achieves both good handling and maximum traction from the driving wheels.
- × These advantages, whilst of great importance for special cars, are outweighed in the case of everyday cars by the fact that the engine takes up space that would normally be occupied by passengers.
- × The mid-engine layout shown combines the engine and transmission components in one unit.
- × The term mid-engine is used because the engine is mounted in front of rear axle line.



Front-engine car



Med-engine car



Rear-engine car

Typical Engine Configurations

The engine may be placed in different positions within the vehicle, each having its own advantages. There are four main engine configurations.

Front engine, front wheel drive can help with the drive-ability of the vehicle.

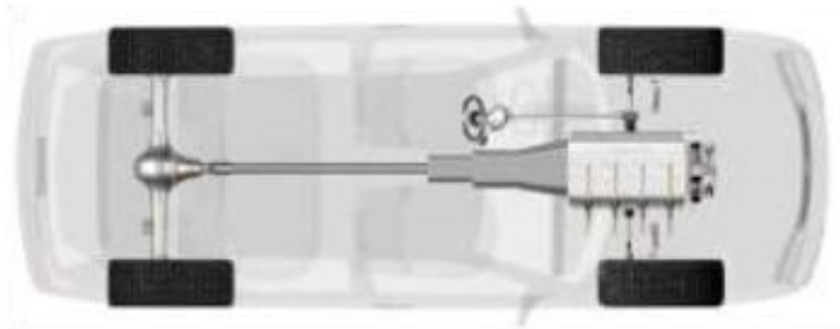
The engine weight over the driven wheels gives greater traction. This can be particularly useful in adverse weather conditions.



Front engine, front wheel drive

The front engine, rear wheel drive configuration has the advantage of better weight distribution.

However, some traction can be lost because the bulk of the weight is not over the driving wheels.

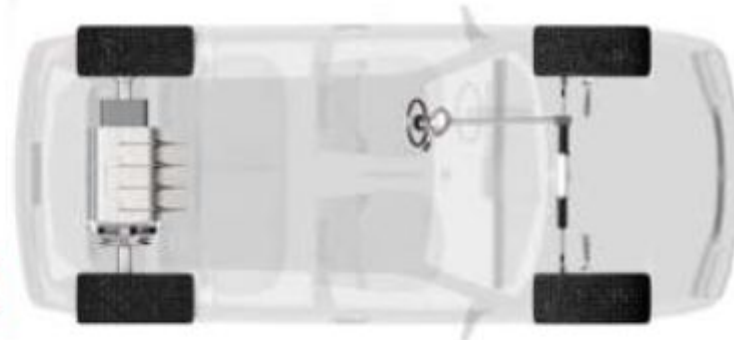


Front engine, rear wheel drive

Rear engine, rear wheel drive

provides a larger load to the rear driving wheels.

However, it can become 'tail heavy' which affects handling of the vehicle. It also reduces luggage space (which is now in the front), as the passenger seats need to be moved forward in order to accommodate the engine.

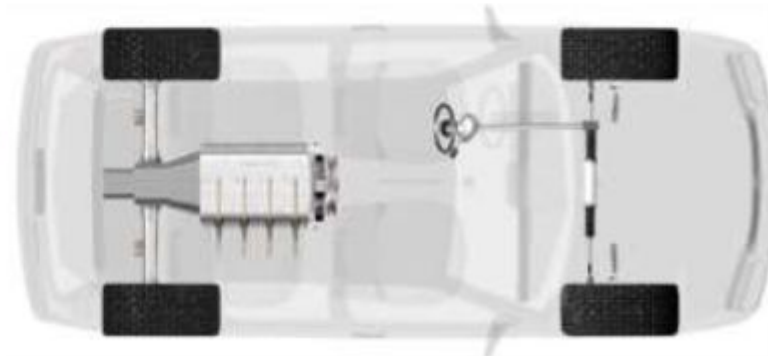


Rear engine, rear wheel drive

Mid-engine, rear wheel drive

engines provide good vehicle handling and good traction at the rear wheels.

They are normally found on two-seat sports cars where these factors are important.



Mid-engine, rear wheel drive

Drive arrangements:

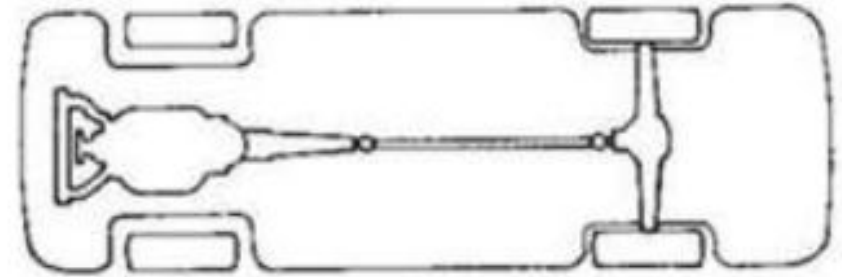
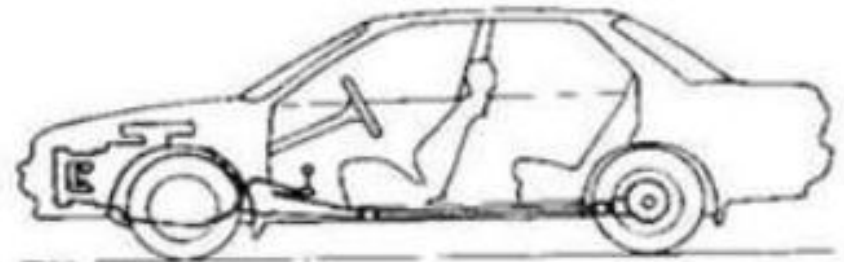
Front engine and rear-wheel drive

Advantages:

- × *Better axle load distribution
- × *Better road grip
- × *Comfort riding
- × *Better cooling
- × *Less noise (long exhaust pipe)
- × *Use a long engine

Disadvantages:

- × *Heavy (more weight)
- × *The passenger compartment has the propeller shaft tunnel.



Rear-wheel drive (RWD)

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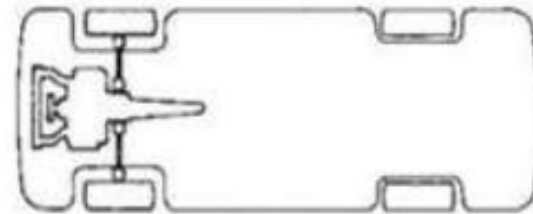
Front engine and front-wheel drive

Advantages:

- × * More space in passenger compartment.
- × * Easy to place the fuel tank (bigger)
- × * More safe in the event of head on collision. (engine mass)
- × * Shorter car length and better passenger compartment
- × * Better cooling
- × * No problem in steering the car in a slippery road.

Disadvantages:

- × * The need to a power steering
- × * More tire wear in the front axle
- × * Less brake efficiency, 75% front and 25% rear.
- × * Less climbing ability
- × * Less accessibility for engine parts (maintenance)



Front-wheel drive (FWD)
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Rear engine and rear wheel drive

Advantages:

- ✕ * Good brake distribution on the axles
- ✕ * Better climbing ability and acceleration
- ✕ * Less steering effort

Disadvantages:

- ✕ * More rear wheel tire wear.
- ✕ * Bad cooling
- ✕ * Less space for luggage
- ✕ * Sensitive to the wind.
- ✕ * Less safety (front fuel tank)



Rear-engine and rear-wheel drive
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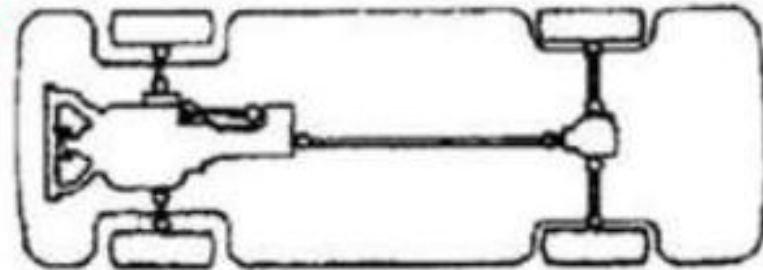
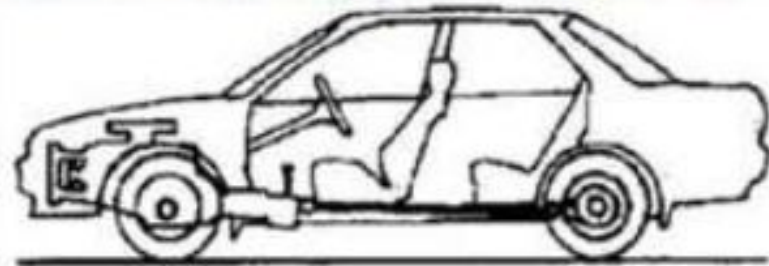
Four-wheel drive

Advantages:

- × * Better traction
- × * Less risk of wheel spin
- × * Minimizes the possibility of wheel lock-up when braking the car.
- × * More gradient ability

Disadvantages:

- × * Heavier
- × * Increase the fuel consumption
- × * Tires wear if driven on a paved road.

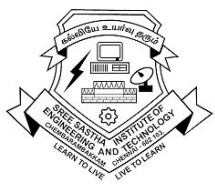


Four-wheel drive

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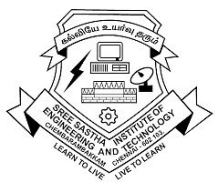
PASSENGER CAR CONSTRUCTION

- Frt Bulk Head/Scuttle Panel – complex Structure – accommodate various controls & equipments
- Body side with thin pillars, large windows & door opening –weak structure – require reinforcement
- Main Centre Floor Panel – sufficient Reinforcement – carry the weight of front seat & passengers
- Centre Floor – Sill provides Longitudinal strength & Cross member provides Transverse strength



METHODS OF IMPROVING SPACE IN CARS

- AXLE Position
- Floor should be placed as low as possible – Centre of Gravity Height low
- Lower CG – Better Stability & Easy Entry/Exit
- Floor Boards – humps for PS
- Integral Body – lower floor
- Wheel Arches – Clearance for Wheels - > 50 mm
- Space Available – Driver's leg Position, Pedals, Boot, Engine Compartment & Passenger Seats
- Spare Wheel – Under the Frt seat or outside the car



METHODS OF IMPROVING SPACE IN CARS

- Small & Medium Sized Cars – Compact Design
- Improved Power /Weight Ratio
- Length of Passenger Car – Engine & Transmission Position
- FMFD – Longest Body
- RMRD & FMRD – Identical length
- RMRD – Easier to Built Floor & More Leg Room for Driver
- Compact Car – Economy of Vehicle Production