Vehicle Body Engineering

BY JDK

Vehicle Body Engineering

Introduction : Basic Feature of an Automobile

- **Progress of civilization is intimately connected with the means of transportation**
- **A self-propelled vehicle used for transportation of goods & passengers on land is called Automobile or Automotive/Motor Vehicle**
- **An automobile is comprised of a chassis & a body**
- **Chassis is made up of a frame supporting ;**

  body / power unit / transmission system / control system

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Introduction : Basic Feature of an Automobile

- ***A chassis frame is supported by wheels & tyres through suspension system and axles***
- ***The power delivered by power unit (engine) is transmitted through clutch or fluid coupling, transmission system, and axle to the wheels***
- ***Automobile is propelled on road due to friction between the tyre and road surface***
- ***Various sub - systems of the automobile are properly designed & held together for efficient functioning individually & as well as whole unit***

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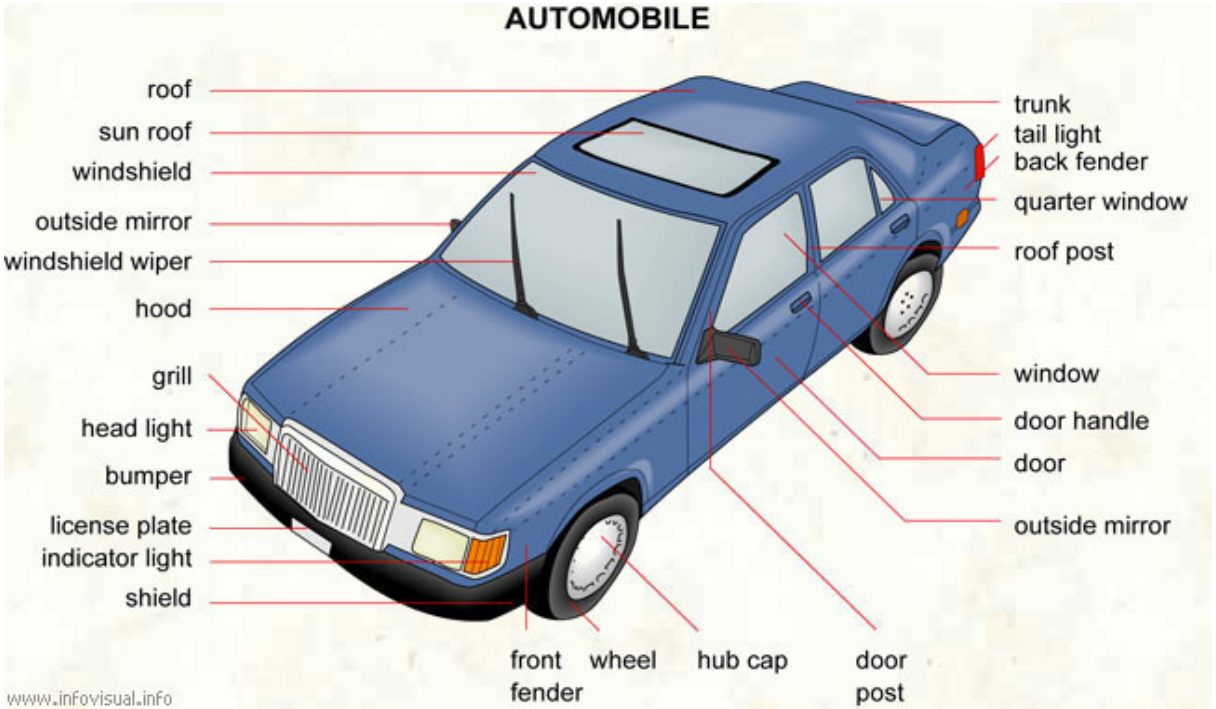
Introduction : Basic Feature of an Automobile

- ***The body and suspension provides protection & comfort***
- ***Automobile has its limitations in regard to load, speed & distance it can travel***



Vehicle Body Engineering

Course Outlines **BADE- 503 LTP-3 1 0**

I: Car Body Details

II: Vehicle Aerodynamics

III: Bus Body Details

IV: Commercial Vehicle Details

V: Body Materials, Trim & Mechanisms

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General Classification of Automobiles

Automobiles can be classified from various point of view of considerations like ;

- ***Use : Motorcycle, car, Bus, …***
- ***Capacity : HTV,LTV, …***
- ***Make : Maruti, Honda, Bajaj, …***
- ***Model : Zen,***
- ***Fuel : Petrol, Diesel, CNG, …***
- ***Wheels : Two, three, four, ...***
- ***Drive : Left hand drive, Front wheel drive, ...***

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General Classification of Automobiles

- *Transmission : Conventional, Automatic …*
- *Construction :*

a) Unitized body construction

- Various body sections are used as structural strength member to help support & stiffen the entire unit

- All sections are welded together to form an unit.

- this eliminates the need of heavy chassis frame

b) Separate Body & Chassis consruction

- The frame is constructed as a separate unit and

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General Classification of Automobiles

body is bolted to it at various points

- The frame must be quite rigid, since the suspension system, engine and body depends upon the frame to support and keep all units in alignment

- ***Types of Vehicle :***

a) Single-unit Vehicles or load carriers

b) Articulated Vehicles

c) Heavy Tractor Vehicles

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General Classification of Automobiles

Types of Vehicle :

a) Single-unit Vehicles or load carriers

- Conventional four wheel types with two axle design

- Front axle is a steering non-driving axle

- Rear axle is driving axle

b) Articulated Vehicles

- Three - wheelers with single steering wheel in front & rear axle as driving axle

- It can turn around its own tail with greater handling ability

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General Classification of Automobiles

Types of Vehicle :

b) Articulated Vehicles

- A coupling mechanism between semi trailer and tractor in most cases designed for automatic connection

c) Heavy - tractor vehicles

- More heavy load tractors or independent tractor vehicles

- Commonly operate in pair either in tandem or as puller or pusher

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General Classification of Automobiles

Types of Vehicle :

c) Heavy - tractor vehicles

- ***Uses number of axles & wheels as drive wheels or otherwise***
- ***Load per axle can be reduced which protects tyres from overloading and road surface from damage***
- ***Wheel axles are called "live" if drive and called "dead" if non-drive***
- ***A live axle supports the payload & driving tractive effort while dead axle supports load only***

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Car Body Details - The Motor Car

- *The passenger car is used for transportation of one to seven passengers in sitting position and accommodates their luggage.*
- *Space is provided for engine, transmission, steering, suspension, braking systems,etc.*
- *It is designed for safety,comfort and economy*

- *Car broadly classified on Body Style as :*

  a) Closed cars ; Saloon, Coupe, …

  b) Open cars ; Sports, Convertible, …

  c) Special Styles ; Estate, Station Wagon, …

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Car Body Details - The Motor Car

- *Saloon : Enclosed compartment to accommodate a row of front & a row of rear seats without any partition. It has fixed roof body with separate luggage compartment. It provides passenger comfort such as; well designed seats, ease of entry & exist, good ventilation system,etc The drag co-efficient is from 0.35 to 0.50.*
- *Hatchback : It is like Saloon with a door at the back*
- *Coupe : It has hard roof with one row of seat for two persons*
- *Convertible : Generally has a soft folding roof, wind-up*

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Car Body Details - The Motor Car

windows, two doors & two seats

- *Limousine : It is luxury car with high quality equipment interior, finish, cushioned seats, air - conditioning. Seating five persons behind driver with sliding glass partition. High roof line allow better head room,etc.*
- *Estate car : It has extended roof with longer wheel base to increase rear space. For access rear door is provided, rear seats are designed to collapse for additional space.*
- *Pick up : Two door front seating van with open back to carry mixed collection of goods.*

Vehicle Body Engineering

Car Body Details - The Motor Car

- *Station Wagon : It has rear doors for luggage seats for four or five persons.*
- *Racing Car : It has very high performance (power) engine. Two doors or less, provided with a collapsible hood, a flood-flat wind screen, and removable side-screens. The drag coefficient may be less than 0.2*
- *Sports Car : A sports car/coupe is a two seater and may have two extra seats at the rear (refered to as 2-plus -2) & two doors. It has fixed roof and high performance engine. Drag coefficient varies from 0.2 to 0.3*

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Car Body Construction

Identification & Functions of Body Pressings

- In a separate body and chassis construction :
  - Chassis resists bending & twisting loads
  - Body provides only functional needs

- Separate body & chassis type of construction is being superseded by the integral or mono-construction system

- In integral construction the frame members become an integral part of the body

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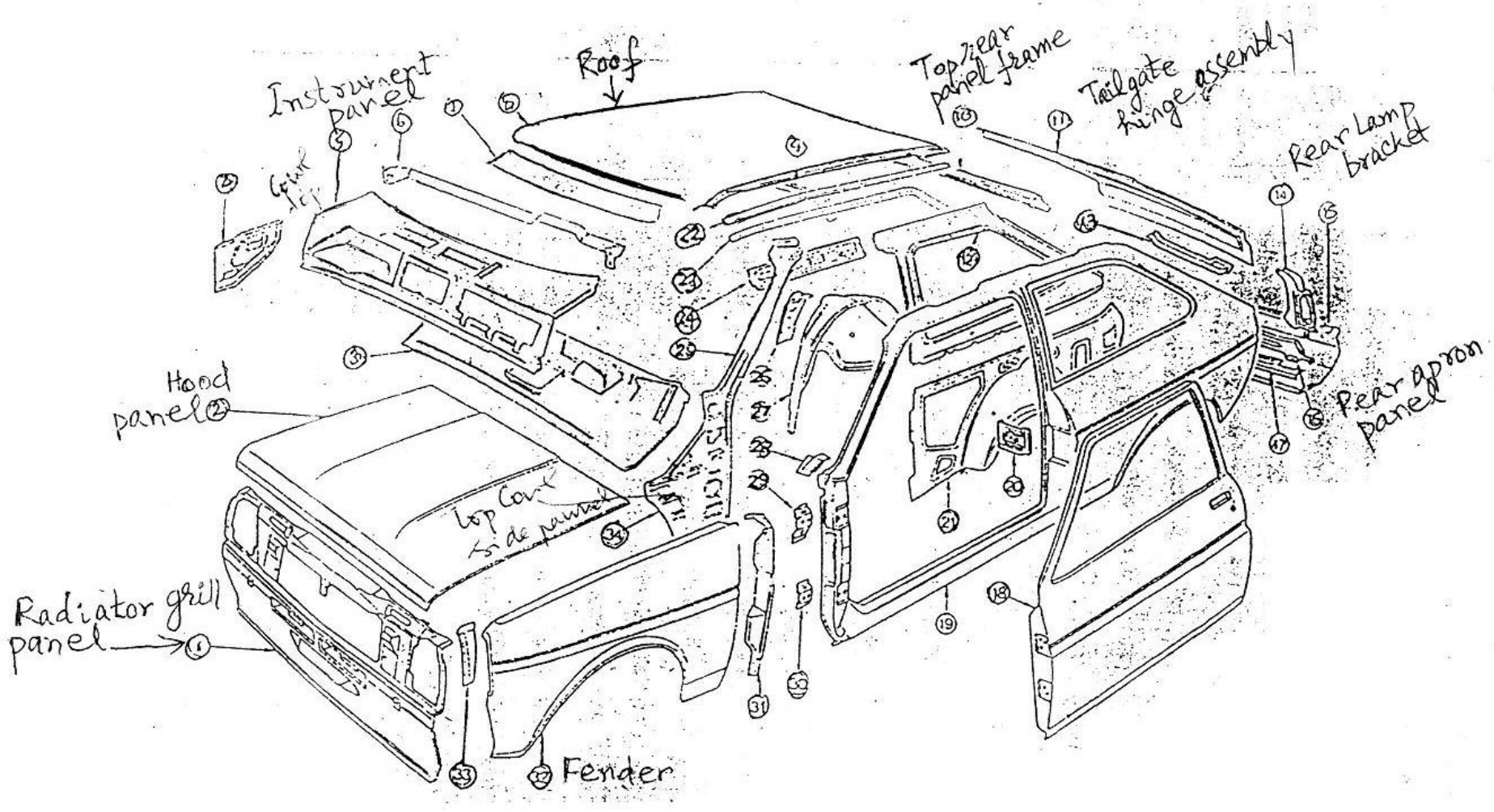
Car Body Construction

Identification & Functions of Body Pressings

- **Car Body Assemblies**



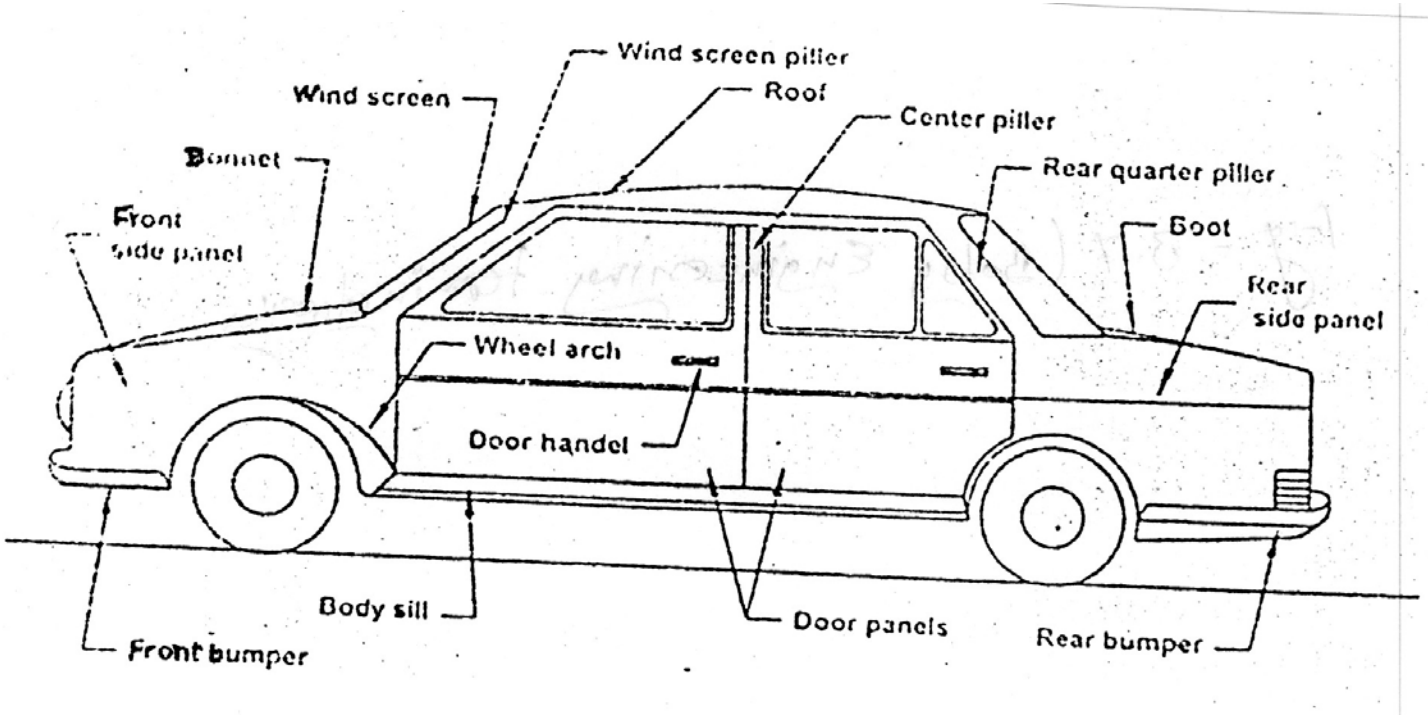
Vehicle Body Engineering

Body Terminology, Visibility & Space

Vehicle Body Engineering

Body Terminology, Visibility & Space

Body Engineering Terminology



- # Tailfin

- The tailfin era of automobile styling encompassed the 1950s and 1960s, peaking between 1957 and 1960. It was a style that spread worldwide, as car designers picked up styling trends from the US automobile industry where it was the *golden epoch* of American autodesign

Center console

The center console in an automobile refers to the control-bearing surfaces in the center of the front of the vehicle interior. The term is applied to the area beginning in the dashboard and continuing beneath it, and often merging with the transmission tunnel which runs between the front driver's and passenger's seats of many vehicles

Fascia

Fascia **often refers to the decorative panels of a car's dashboard or the entire dashboard assembly**

Fender skirts

Fender skirts, known in Australia and the United Kingdom as spats, are pieces of bodywork on the fender that cover the upper portions of the rear tires of an automobile

Glove compartment

A glove compartment or glovebox or glovie is a compartment built into the dashboard, located over the front-seat passenger's footwell in an automobile often used for miscellaneous storage

Greenhouse

The greenhouse (or glasshouse) of a car comprises the windshield rear and side windows, the pillars separating them (designated A-pillar, B-pillar and so on, starting from the car's front), and the car's roof

Hood scoop

A bonnet/hood scoop, sometimes called bonnet airdam/air dam, or colloquially speed hole, is an upraised component on the hood of an automobile that either allows a flow of air to directly enter the engine compartment, or appears to do so

Nerf bar

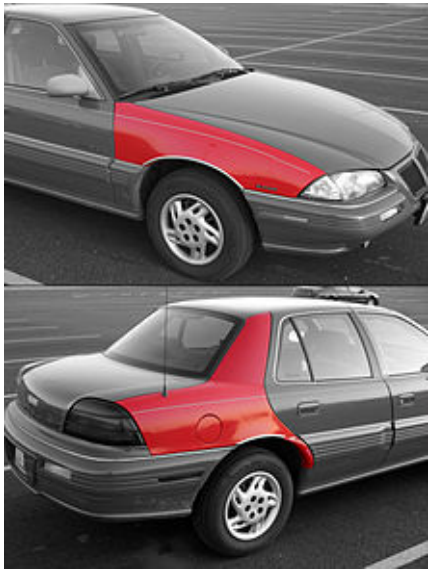
A nerf bar is a tubular device fitted to the side of a racecar, typically single-seat race cars that compete on asphalt or dirt oval tracks. A "nerf" is a small, sometimes intentional, collision between two cars in which one driver bumps the other to facilitate a successful pass. The nerf bar protects the sides of the vehicles and also keeps their tires from becoming entangled

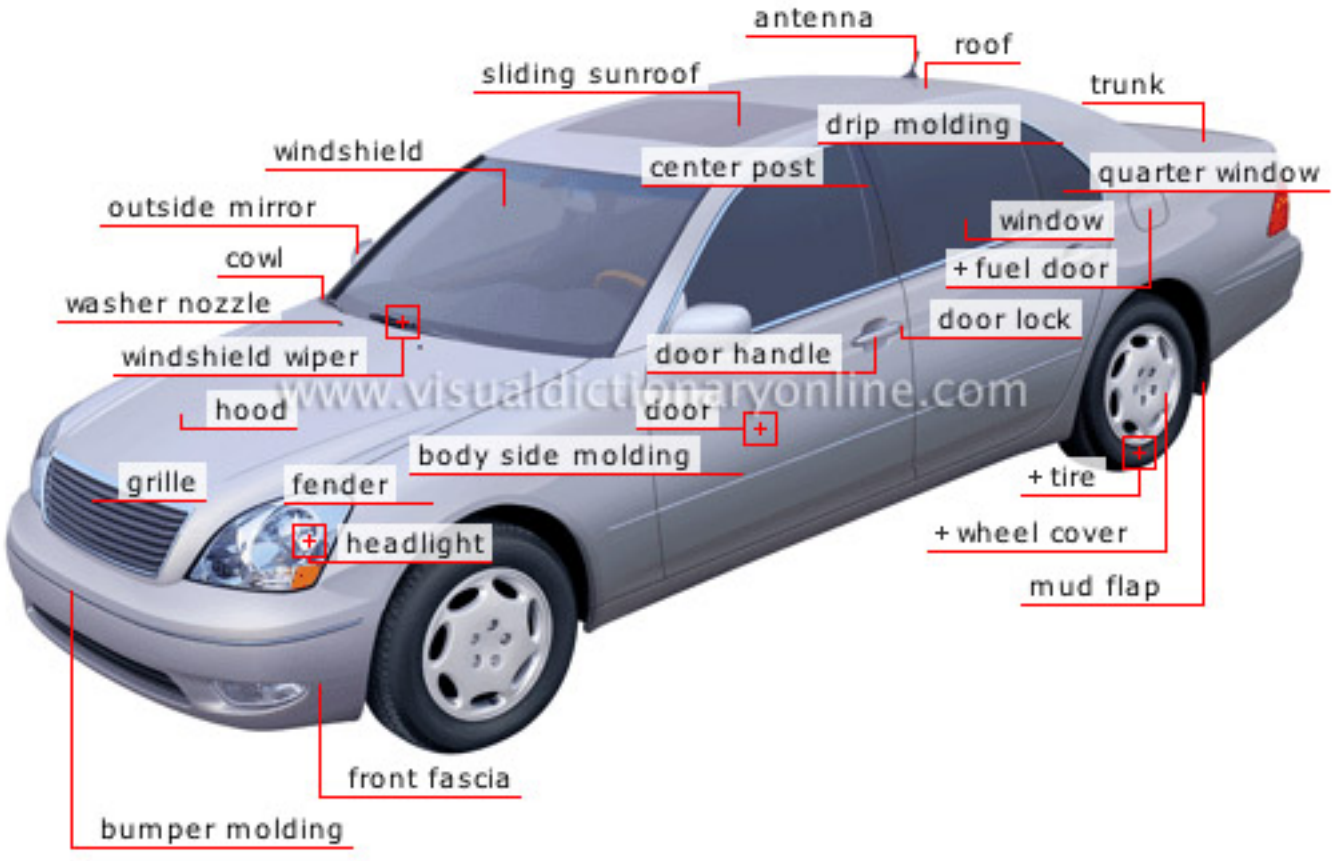
Power bulge

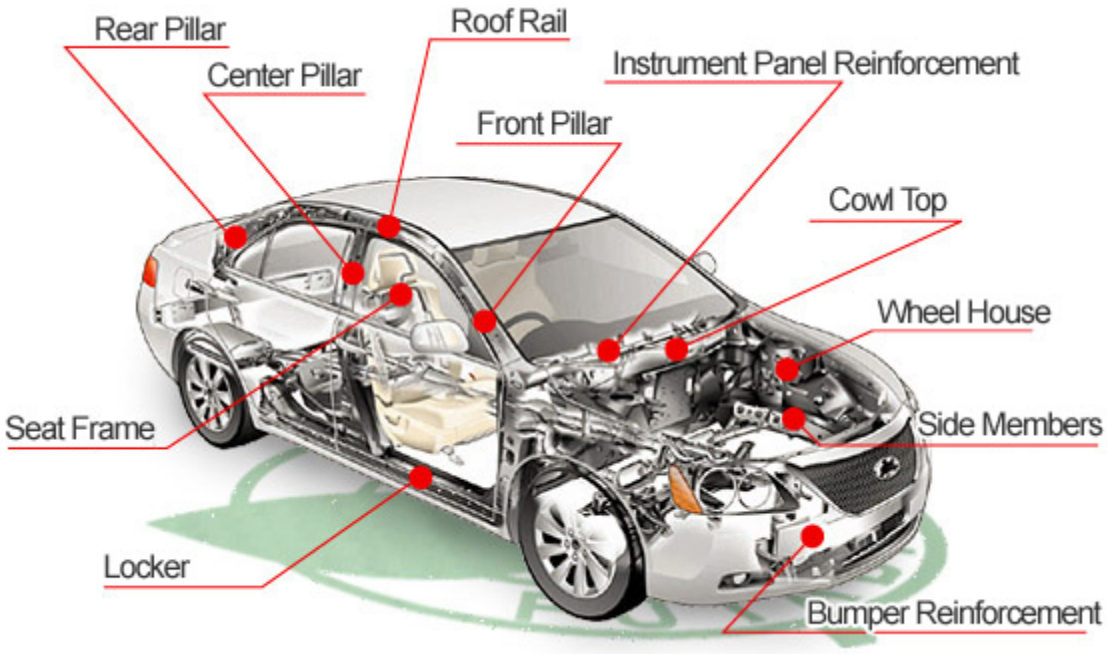
A power bulge is a raised part (a bulge) of the hood of a car. The reason for a power bulge is to fit for instance a large engine or air filters that otherwise would not fit. Sometimes a power bulge is used to be able to fit a larger engine into a car that originally was not designed for it or it may be a design choice to be able to get a lower profile. As a power bulge is associated with performance cars it may also be used as a design element to give the impression of a fast car

Quarter panel

A quarter panel is the body panel (exterior surface) of an automobile between a rear door (or only door on each side for two-door models and the trunk (boot) and typically wraps around the wheel well. The similar front section between the door and the hood (bonnet) , is called a fender but is sometimes incorrectly also referred to as a quarter panel. Quarter panels are typically made of sheet metal, but are sometimes made of fiberglass or fiber-reinforced plastic




antenna
roof
sliding sunroof
trunk
drip molding
windshield
center post
quarter window
outside mirror
window
cowl
+ fuel door
washer nozzle
door lock
windshield wiper
door handle
www.visualdictionaryonline.com
hood
door
body side molding
grille
fender
+ tire
+ headlight
+ wheel cover
mud flap
front fascia
bumper molding


Rear Pillar
Roof Rail
Center Pillar
Instrument Panel Reinforcement
Front Pillar
Cowl Top
Wheel House
Seat Frame
Side Members
Locker
Bumper Reinforcement

Vehicle Body Engineering

Body Terminology, Visibility & Space

Body Engineering Terminology

- **Body Sill : The panel (metal plate) directly below the bottom of doors supporting the floor and may be used to combine floor & body.**

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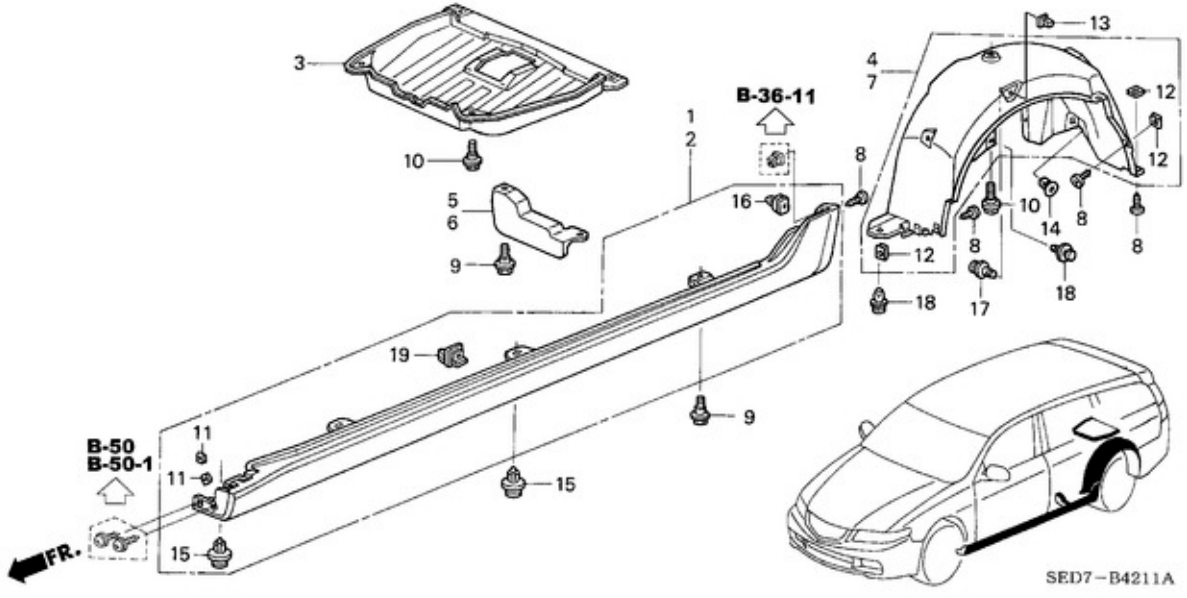

- Bonnet : The metal cover over the engine compartment
- Bulk Head : A transverse support or assembly in a body structure.
- Boot : A compartment which takes luggage and often the spare wheel & fuel tank
- Center Pillar : The central vertical support of a four door saloon, sometimes referred to as B-C post

Vehicle Body Engineering

Body Terminology, Visibility & Space

Body Engineering Terminology

- Cant Rail : The longitudinal framing of the roof at the joint
- Cant Panel : The curved section of the roof top running between the comparatively flat top and the rain channel
- Door Skins : Door exterior panels/outside door panels
- Door Trim : The interior lining of a door
-

- **Drip Moulding : A roof gutter to direct water from door openings**

- **Fire wall : Panel dividing engine compartment from passenger compartment**

Vehicle Body Engineering

Body Terminology, Visibility & Space

Body Engineering Terminology

- Head Lining : The material, cloth, PVS, etc.
- Heel Board : A vertical board or panel rear seat which forms the support for the seat cushion
- Hinge Pillar : A pillar on which the door swing open or close
- Pillar : A vertical support of a body frame
- Quarter Panel : The curved side panels extending from the door to the rear end of the body including the wing or the curved panels which connect the side panels, including the rear wing

Vehicle Body Engineering

Body Terminology, Visibility & Space

Body Engineering Terminology

- Quarter light : The window directly above quarter panel
- Scuttle Panel: The panel between bonnet & windscreen
-

Sub- frame : Members to which the engine & front-end assembly are attached

Vehicle Body Engineering

Body Terminology, Visibility & Space

Body Engineering Terminology

- Sub- frame : Members to which the engine & front-end assembly are attached
- Tunnel : A raised floor panel section for drive shaft clearance
- Wheel arch : A break in the rear panels to accommodate the rear mudguards and wheels

Vehicle Body Engineering

Body Terminology, Visibility & Space

Body Engineering Terminology

- Bearers : The cross- members that support the body floor. They are located on either chassis member or longitudes
- Bulker : A general term for vehicles carrying liquid and powder
- Cab : The part of a vehicle enclosing the driver
- Cant rail : The member which connects the side panels of vans to the roof structure

Vehicle Body Engineering

Body Terminology, Visibility & Space

Body Engineering Terminology

- Cleat : Bracket used for joining longitudinal transverse body members
- COE : Abbreviation for “cab over engine”
- CV : Abbreviation for “commercial vehicle”
- Drop side panels : Hinged panels which are fitted to the sides of platform bodies
- GRP : Abbreviation of glass reinforced plastic used for vehicle roofs and vehicle cab
- GVW : Gross Vehicle Weight is total weight of vehicle
- Longitudes : The main longitudinal members of a body

Vehicle Body Engineering

Body Terminology, Visibility & Space

Body Engineering Terminology

which normally rest upon the chassis

- Overhang : The dimension from the center-line of the rear axle to the rear of the body
- Pay load : The difference between gross vehicle weight and unladen weight , that is carrying weight of vehicle
- Rave : Often referred to as bottom rail, this is the longitudinal section which mates with the outer extremities of the floor & bearers and in case of vans, connects with the side panel
- Rub rail : A longitudinal section fitted to van sides in

Vehicle Body Engineering

Body Terminology, Visibility & Space

Body Engineering Terminology

order to minimize damage to side sheets

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Body Terminology, Visibility & Space

- **Requirements of Automobile Body**

A frameless type body of an Automobile must satisfy requirements in terms of :

- ➔ **Strength**
- ➔ **Stiffness**
- ➔ **Space**
- ➔ **Air Drag**
- ➔ **Protection against weather**
- ➔ **Resistance to Corrosion**
- ➔ **Protection in accident**

Vehicle Body Engineering

Body Terminology, Visibility & Space

- **Strength : Body must withstand all types of forces to which vehicle is subjected to ;**

  - weight of the vehicle, passenger, luggage

  - inertia, braking, & side forces

  - impact loads of reasonable magnitude

- **Stiffness : Body may be considered as a beam supported on wheels at each end. It must possess sufficient stiffness to prevent sagging in the middle.**
- **Torsional Stiffness : Body should be sufficiently rigid to resist twisting on bad roads.**
- **Space : Adequate space to be provided in the body for passenger and luggage.**

Vehicle Body Engineering

Body Terminology, Visibility & Space

- **Air drag : Resistance of air during vehicle movement depends upon body shape. The shape of the body should be such that the air drag is minimum**
- **Protection against weather : Body should be such that the occupants and luggage not affected from weather.**
- **Resistance to Corrosion : Body should be designed such that no moisture is accumulated and material should be such that rust & corrosion does not take place.**
- **Protection in accident : It is an important consideration of vehicle body design. Driver must be at maximum ease to avoid accident due to fatigue. However, body should be designed such that the occupants are best protected even in case of accident**

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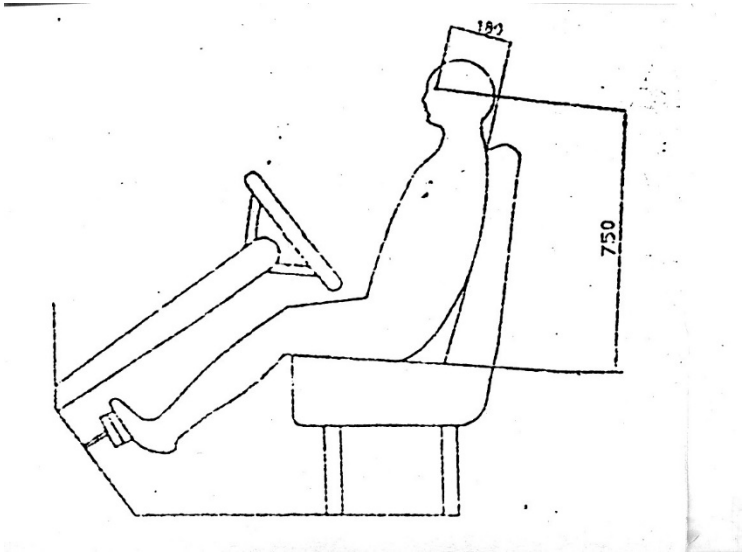
Body Terminology, Visibility & Space

Visibility

- Good all round visibility is one of the main requirements of body design

  - Visibility depends upon the window opening and their relative position to the occupants

  - Figures below show eye position of driver, angle of visibility & space between the pillar and seat



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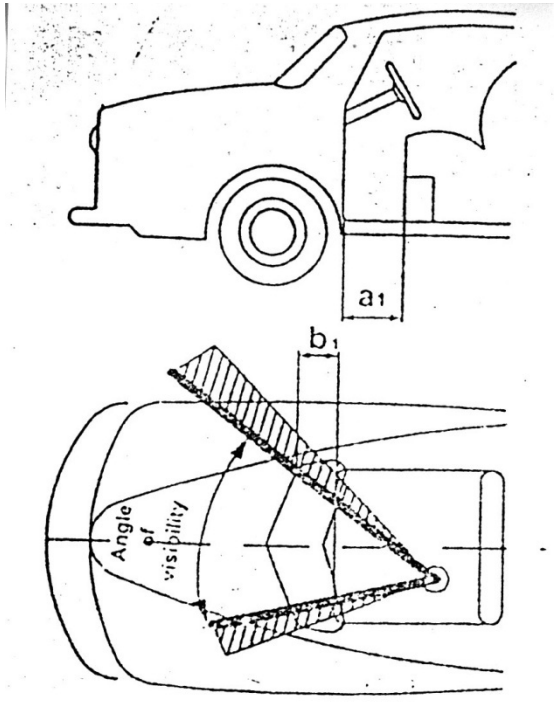
Body Terminology, Visibility & Space

Visibility



Improvement in Frontal visibility

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Body Terminology, Visibility & Space

Visibility

- **Types of Visibility**

  - If occupant is placed close to windscreen the forward visibility is considerably improved but comfortable entry is adversely affected as dimension between pillar & seat is decreased requiring suitable shaping of the door, if possible.

  - Downward visibility can be improved by positioning the driver as high as possible in relation to the lower edge of windscreen.

  - Rearward visibility is achieved by increase in glass area required to maintain rear view vertical angle with back window

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Body Terminology, Visibility & Space

Space Requirements & Methods of its Improvements

- Amount of space has to be allocated to passenger needs according to dimension & type of body
- Space for access to fuel tank, spare wheel, batteries, tools, boot, and spare wheel placing, etc. depend upon dimension & type of body and the inventiveness of the designer.
- Window opening should ensure good visibility without affecting stiffness of the body shell.
- Main requirement of door opening is the comfort of entry

In two door design passage way to back seat should be ensured

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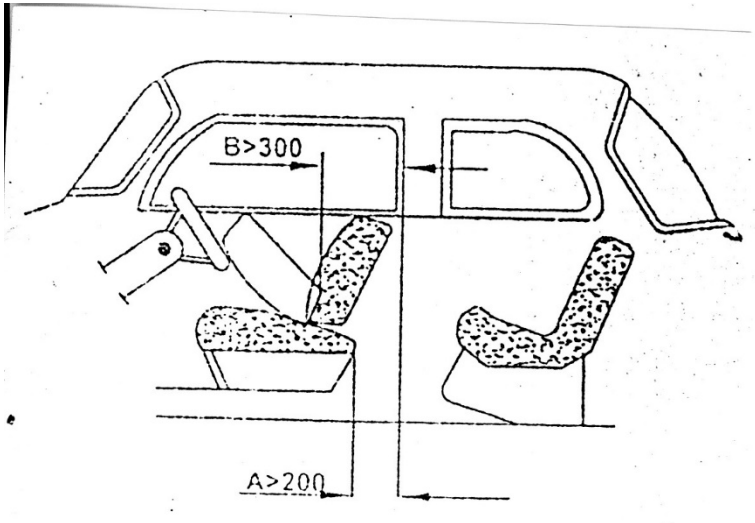
Body Terminology, Visibility & Space

Space Requirements & Methods of its Improvements

Measurement of comfortable passage way is shown in figure.



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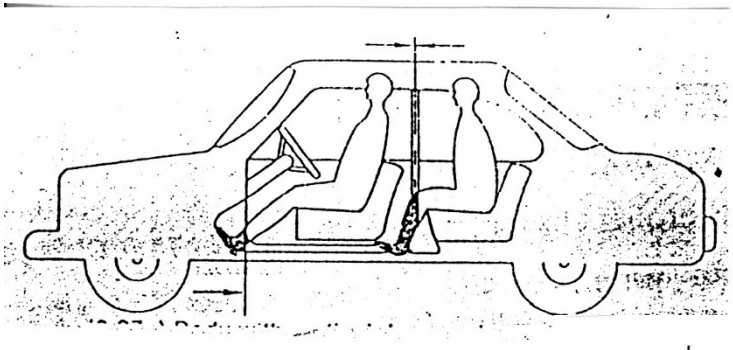
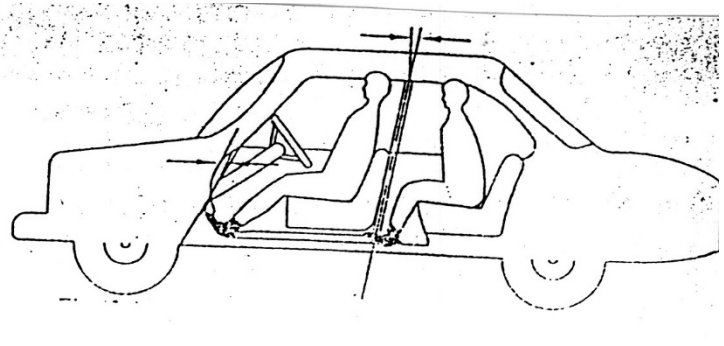
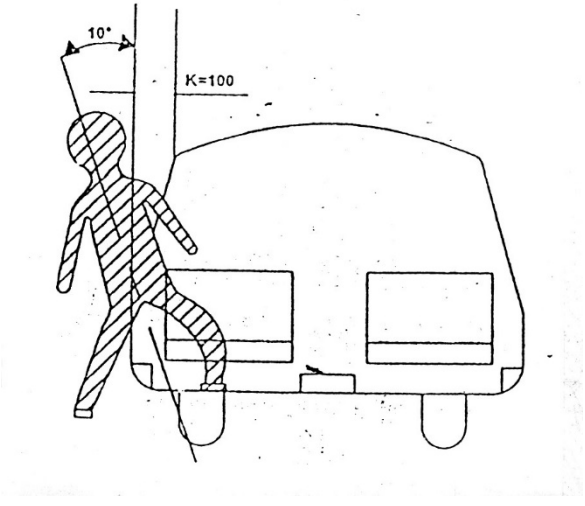
Body Terminology, Visibility & Space

Space Requirements & Methods of its Improvements

- Avoid pockets for the feet by sloping the door post & side walls as shown.







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Body Terminology, Visibility & Space

Space Requirements & Methods of its Improvements

- Considerable experience in design is needed to position the compartments in a planned outline of the body.
- Good utilization of space is particularly significant for small vehicles and in general makes the vehicle lighter resulting in improved power-to-weight ratio. This reduces cost of vehicle also.

Vehicle Body Engineering

Design Considerations & Body Construction

Vehicle Body Engineering

Design Considerations & Body Construction

Morphology of Vehicle Body (Structural) Design

- **Emancipation of the Body Designer**

  - A wide range of skills required for vehicle design and manufacture

  - Development of motor vehicle may require following group of activities;

  - **Technical innovation and refinement**
  - **Construction and configuration by Designing & Styling**
  - **Methods of production, and manufacturing systems**

Vehicle Body Engineering

Design Considerations & Body Construction

Morphology of Vehicle Body (Structural) Design

- **Technical innovation and refinement**

- Innovative developments have often been the work of several different engineers working in parallel but independently

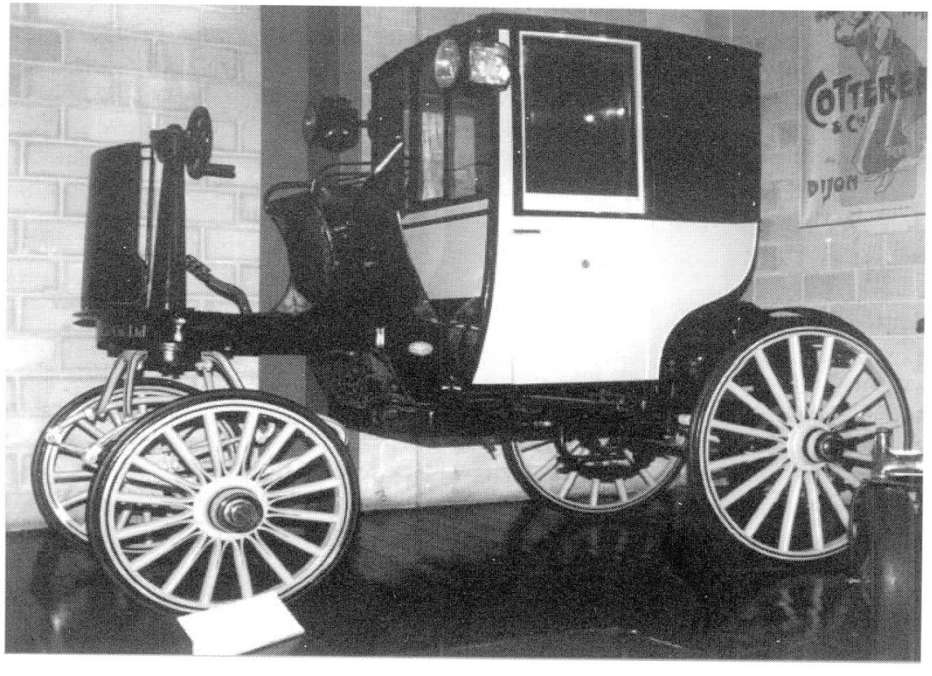
- Many apparently new inventions are adaptations from different technologies, e.g.,

differential mechanism used by watchmakers, aerospace, electronics, materials,etc.

Vehicle Body Engineering
Design Considerations & Body Construction

Morphology of Vehicle Body (Structural) Design

- Construction and configuration by Designing & Styling
  - Methods of production and manufacturing systems in early times were adaptations from horse-drawn carriage construction methods for upper body works.



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Design Considerations & Body Construction

Morphology of Vehicle Body (Structural) Design

- Construction and configuration by Designing & Styling

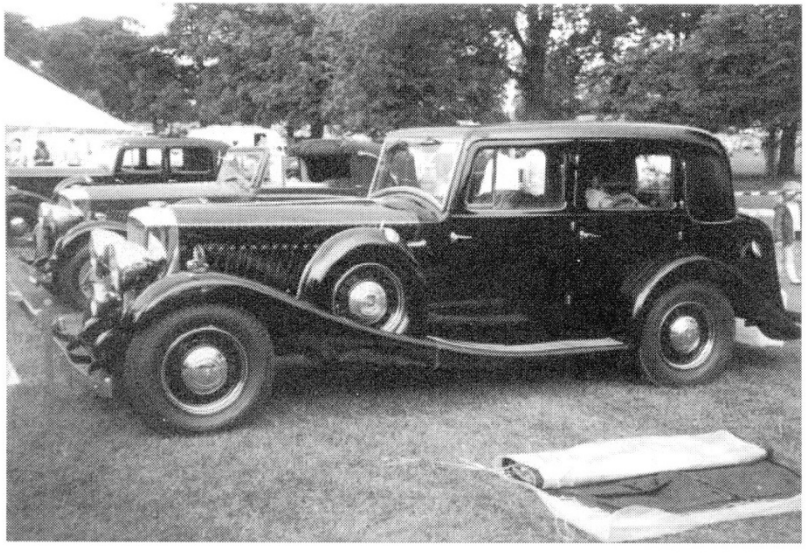
  - Above a wooden chassis, sat a light wooden framework covered with a skin of sheet metal, wood or fabric.

  - As motor vehicles had to sustain loads and vibrations of engine, transmission and of vehicle dynamics at higher speeds (higher shock loads) the metal chassis frame were quickly adopted

Vehicle Body Engineering
Design Considerations & Body Construction

Morphology of Vehicle Body (Structural) Design

- Construction and configuration by Designing & Styling
  - A combination of steel chassis, wooden framework and sheet metal skinning were used for most vehicle with aluminum often used in more expensive and higher performance vehicles



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Design Considerations & Body Construction

Morphology of Vehicle Body (Structural) Design

- Construction and configuration by Designing & Styling

  - A few fabric and wooden bodied vehicles were still produced as late as 1930s by specialist coach builders mainly because the antiquated style conveyed an air of past elegance.

  - Subsequently increasing use of pressed – steel skin panels in place of flat sheets or hand beaten or wheeled panels followed.

Vehicle Body Engineering
Design Considerations & Body Construction

Morphology of Vehicle Body (Structural) Design

- Construction and configuration by Designing & Styling
  - Sheets of steel were pressed in moulds to produce complex shapes with multiple curvature and the process enabling economic production bulbous styling forms, that became popular, took over

Vehicle Body Engineering
Design Considerations & Body Construction

Morphology of Vehicle Body (Structural) Design

- Construction and configuration by Designing & Styling

  - Multiple curvature also made panels much stiffer and the skin could take a significant part of load.

  - Some manufacturers began to dispense with wooden frames and use metal frame or even no frame work at all, relying on panels & formed sheet metal stiffening elements to provide all rigidity necessary for upper body

Vehicle Body Engineering
Design Considerations & Body Construction

Morphology of Vehicle Body (Structural) Design

- Construction and configuration by Designing & Styling
  - Lower chassis frames initially retained but separate chassis began to disappear, being replaced by a stiff floor 'pan' that was fabricated from welded shaped sheet elements.
  - By 1950s 'unitary' type of construction was almost universally adopted for mass-produced cars.
  - Recently, the shell construction has been refined to produce smooth aerodynamically shape with minimum protrusions or gaps.

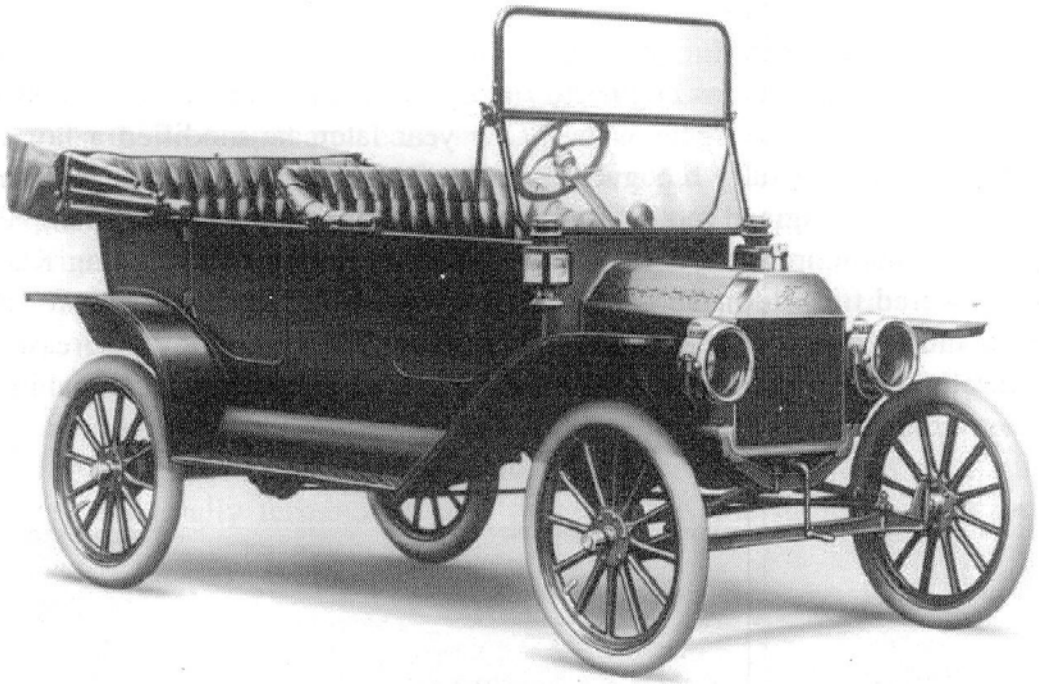
Vehicle Body Engineering
Design Considerations & Body Construction

Morphology of Vehicle Body (Structural) Design

- Construction and configuration by Designing & Styling
  - Composite construction in fiberglass and resin was developed soon after the war

Vehicle Body Engineering
Design Considerations & Body Construction

- **Mass Production - Designing & Styling**
  - **Two giants of vehicle manufacture following World War I were Ford and General Motors**
  - **Initially Ford were predominant with standardized Model-T car & van**



Vehicle Body Engineering
Design Considerations & Body Construction

- **Mass Production - Designing & Styling**
  - Ford fathered mass production and design standardization.
  - GM in addition recognized another strong force in the market place: customers personal preference
    - sectorized market & designed accordingly
    - offer proliferation of body shapes & colours
    - in mid 20s GM gave birth to ‘ Stylist’
  - GM was outselling Ford. Serious business of body design took its place amongst industry professionals.
  - A stylist would ‘package’ occupants and luggage around a fairly standardized layout of engine and drive train.

Vehicle Body Engineering

Design Considerations & Body Construction

Design Considerations

- Task Assignment
- General layout
- Artistic utilitarian design
- Dummies & models
- Preliminary design
- Body weight, stress, geometric analysis, etc.
- Master model and mathematical models
- Scanning of master model with electronic sensors and compilation of data
- Scanned data integration and analysis with the help of

Vehicle Body Engineering

Design Considerations & Body Construction

Design Considerations

computers to generate geometrically perfect surfaces & reproduction of tapes

- Tapes are used by numerically controlled machines (e.g. milling) to prepare high precision dies
- These dies are used by Power Presses to produce the Pressed Metal Panels which are welded together to construct the structures and body of the vehicle

Vehicle Body Engineering

Design Considerations & Body Construction

Design Considerations

Task assignment :

- The task of designing of vehicle is broken down into various components ;

Body / Chassis / Engine / Transmission

- Consider components need to be designed and the components to be used as standard items, e.g, transmission system.

- Consider ergonomics of seating &controls, legal requirements of body, engine, etc. field of vision, aerodynamics, etc.

Vehicle Body Engineering

Design Considerations & Body Construction

Design Considerations

General layout :

- Designer in consultation with Stylist prepares perspective drawings & sketches

- Construct suitable models or mock-ups and initial design drawings

- Carryout structural analysis on body design and compare new design with existing designs to ensure some advances made

- Finalize basic dimensions, often called ‘ package of the vehicle ‘ and include overall dimensions as per legal requirements

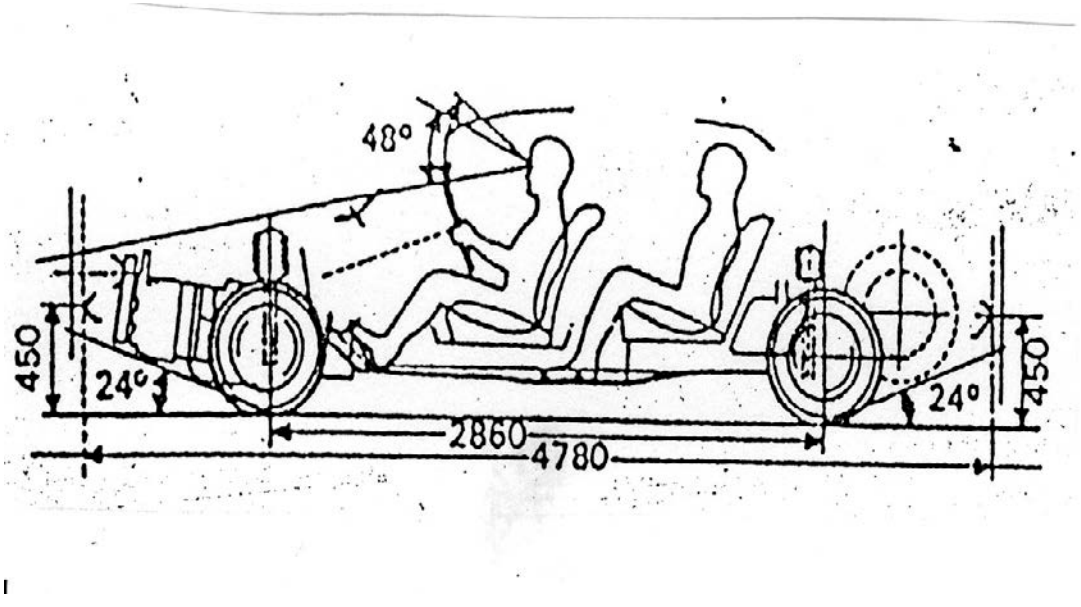
Vehicle Body Engineering

Design Considerations & Body Construction

Design Considerations

General layout :

- As per above the external dimensions, wheel-base, etc. are decided and a general layout is prepared as shown :



Vehicle Body Engineering

Design Considerations & Body Construction

Design Considerations

Artistic Utilitarian Design :

- Aesthetically pleasing body shape is set out considering aerodynamics and other design requirements

- The design of a shape based on the elements of functions and logic together with an artistic appreciation of forms is called " artistic utilitarian design ". Such designs have advantage over irrational styling and is a necessary part of good design.

Vehicle Body Engineering

Design Considerations & Body Construction

Design Considerations

Dummies & Models :

- The dimensionally complicated form of vehicle bodies require practical checking at all stages of design. These are carried out by means of dummies and models

Dummies :

- Dummies are built to ensure that the principal dimensions are compatible. This includes dimensions of driver's position, passenger's seat, size of door & window openings, etc.

Vehicle Body Engineering

Design Considerations & Body Construction

Design Considerations

Dummies & Models :

- A full scale dummy allows for complete reproduction of the drawing dimensions and thus check for comfort, visibility, ease of exit & entry, position of steering wheels, chassis - engine mechanisms, layout of dashboard, etc.

- Dummies are usually constructed in timber and / or other synthetic materials which are easy for manual working.

- Apart from checking dimensions of the body the position of components can be determined using

Vehicle Body Engineering

Design Considerations & Body Construction

Design Considerations

Dummies & Models :

chassis & engine either real or their dummies

Models :

- Inside dimensions of a vehicle body, having being checked & finalized with dummies, form the basis for developing models of the outside surfaces of the body.

- Scale models (say 1 in 20) are constructed using materials like plasticine or plaster of paris laid on a wooden base with tools such as knives & spatulas, etc. Some scribing devices are used as measuring

Vehicle Body Engineering

Design Considerations & Body Construction

Design Considerations

Models :

the principal sections (called outlines) are transferred onto the model using templates.

- A few variants of a model with corrected basic sections of the design are considered for finally choosing the model for obtaining templates for larger scale models (say 1 in 5) such that it represents vehicle in details as far as possible. Such a model is called a “ reduced model “

- the principal dimensions of the vehicle are determined by the development of such models and

Vehicle Body Engineering

Design Considerations & Body Construction

Design Considerations

Models :

and dummies, and the first outlines of the drawings can be made without details.

Vehicle Body Engineering

Design Considerations & Body Construction

Material Requirements and Body Parts

- **Steel Sheets used for making Car Bodies :**

  - Low tensile strength and high ductility for ease of forming

  - Easily assembled to form a body unit

  - Light in weight

  - Low cost

- **A Typical Low-Carbon Steel Composition**

Carbon	**- 0.080 %**	**Phosphorus**	**- 0.020 %**
Silicon	**- 0.002 %**	**Manganese**	**- 0.350 %**
Sulfur	**- 0.020 %**		

Vehicle Body Engineering

Design Considerations & Body Construction

Material Requirements and Body Parts

- The liquid steel is cast into large ingots for subsequent hot - rolling to sheets of different thickness. Typical sheet thickness & their use are :

10g	3.25mm	brackets & supports and heavy
12g	2.65mm	internal construction
14g	2.03mm	panel assemblies which take
16g	1.63mm	stresses & loads (floor bulk head,
18g	1.22mm	sills, sub-frames, cross-members
		and inner stress panels)

Vehicle Body Engineering

Design Considerations & Body Construction

Material Requirements and Body Parts

20g	0.95mm	outer panel construction (skin
22g	0.71mm	panels, doors, bonnet, boot, lid,
		wing panels)

Vehicle Body Engineering

Design Considerations & Body Construction

Material Requirements and Body Parts

- **Comparison between Steel & Aluminum**

  - The requirements of Fuel Economy & Environment has demanded Vehicle Body weight reductions.

  - Aluminum has been considered strong alter native to steel in order to achieve weight reduction. However, the magnitude of weight reduction has to be attractive despite its higher cost.

  - Generally, Aluminum has been found better in castings for housing, engine blocks, etc resulted in savings in weight & costs

Vehicle Body Engineering

Design Considerations & Body Construction

Material Requirements and Body Parts

- **Comparison between Steel & Aluminum**

  - The compelling demand for change in material properties has been the need for reduced weight

  - To meet such demand a new generation improved high-strength steels has been developed that offer :

    I) sufficient ductility to meet fabrication requirements

    ii) meets the minimum yield strength requirements

    iii) improved conductivity & weldability

Vehicle Body Engineering

Design Considerations & Body Construction

Material Requirements and Body Parts

- **Comparison between Steel & Aluminum**

- Comparison of Relative Material Properties of Aluminum (Base Steel = 1)

I)	**Tensile Strength**	**1/3**
ii)	**ductility**	**1/2**
iii)	**density**	**1/3**
iv)	**elastic modulus**	**3**

Vehicle Body Engineering

Design Considerations & Body Construction

Material Requirements and Body Parts

- **Comparison between Steel & Aluminum**

  - Considerations for Competitiveness

  For tensile strength limited applications replacement of steel by aluminum requires a cross-section that is three times greater which makes it approximately equal in weight for equivalent modulus of elasticity. Overall it means three times the cost.

Vehicle Body Engineering

Design Considerations & Body Construction

Material Requirements and Body Parts

- **Comparison between Steel & Aluminum**

Factors for material selection for Car Body Pressings

- Yield strength
- failure strength
- formability
- indentation resistance
- fabricability
- painting systems / requirements
- Welding
- Heat - Treatment

Vehicle Body Engineering

Design Considerations & Body Construction

Material Requirements and Body Parts

- **Comparison between Steel & Aluminum**

Some Comments / Observations

- Most automotive components are not loaded in pure tension, but where simple tensile properties are the design criteria, a steel with higher yield strength is capable of saving about 40% of weight and may be comparable .

- Functional requirements vary from simple bending or indentation resistance to complex twisting and structural loading of components. By changing to higher-strength steel, appreciable weight reductions

Vehicle Body Engineering

Design Considerations & Body Construction

Material Requirements and Body Parts

- **Comparison between Steel & Aluminum**

Some Comments / Observations

can be obtained. The type of improvements generally achieved by increasing the product strength can be as high as 30%.

- Welding : Aluminum parts require increased thickness (1.4 times) and larger dia. Electrodes for welding & greater edge distances for equivalent weld-bond strength. Disparity increases as thickness increases. At about 2.2mm steel provides 3 times strength advantage.

Vehicle Body Engineering

Design Considerations & Body Construction

Material Requirements and Body Parts

- **Comparison between Steel & Aluminum**

Some Comments / Observations

Welding :

- In order to improve inherent lack of spot weldability of aluminum sheets the adhesive bonding & welding may be used to achieve satisfactory strength. This may have additional cost implications.

- Oxide coating of aluminum vary significantly and cause production of unacceptable welds.

Vehicle Body Engineering

Design Considerations & Body Construction

Material Requirements and Body Parts

- **Comparison between Steel & Aluminum**

  Some Comments / Observations

  In summary, steel has many inherent advantages over aluminum for applications in pressings however, aluminum has advantage in castings for housings, engine blocks, etc.

Vehicle Body Engineering
Body & Safety Considerations

Vehicle Body Engineering
Body & Safety Consideration

Introduction

- Designer should ensure maximum safety of the driver, passenger, and other road users
- Vehicle should be designed to reduce the effects of collision and ensure minimum injury
- Stylists should avoid sharp ornaments, edges and projected elements. Careful attention to door handles, mirrors, hooks, control knobs,etc. reduces injury to pedestrians and also affects in reduction of aerodynamic drag & noise.

Vehicle Body Engineering
Body & Safety Consideration

Safety Features Of Vehicles can be grouped as :

- **Vehicle Body Structure, its Systems & Parts**
- **Additional Safety Features & Systems**
- **General & other safety recommendations**

Vehicle Body Engineering
Body & Safety Consideration

Safety Features Of Vehicles :

- **Vehicle Body Structure, its Systems & Parts**
  - ➔ Basis of body design for safety
  - ➔ Safety features of Door system
  - ➔ Window Glasses & Windscreen
  - ➔ Bumpers
  - ➔ Seat back & head restraints
  - ➔ Rear view mirrors
  - ➔ Ventilation

Vehicle Body Engineering
Body & Safety Consideration

Vehicle Body Structure, its Systems & Parts

- **Basis of body design for safety**

  - The design of vehicle body for optimum characteristics should be based on basic energy relationship

  - The kinetic energy of a vehicle destroyed during a collision is absorbed by the workdone on materials by elastic deformation

Vehicle Body Engineering

Body & Safety Consideration

Basis of body design for safety

The kinetic energy of a vehicle destroyed during a collision can be expressed as

$$K.E = (m - \nabla m) V^2 / 2$$

where ;

m = total mass of vehicle

∇m = moveable mass(passenger or load)

V = Velocity

Vehicle Body Engineering

Body & Safety Consideration

Workdone on materials by elastic deformation is

$$\int Pds = (\sigma^2 / 2E)\ A\ L$$

where; **P = force generated during collusion on vehicle structure**

S = distance traveled during the collision

E = Young's modulus, Stress/Strain

A = cross sectional area of the structure

σ = local stress in the material

L = deformation in cm

Vehicle Body Engineering
Body & Safety Consideration

Vehicle Body Structure, its Systems & Parts

- **Safety Features of Door System**

  - Photo - electric beam door closes automatically at pre - determined time

  - Gear shift lock prevent selection of gear until all exit doors are closed

  - Electrically sensitive edge on exist door causes automatic opening if obstruction is encountered

  - Pneumatic - sensitive - edges give audible and visual warning to the driver of door obstruction

Vehicle Body Engineering
Body & Safety Consideration

Vehicle Body Structure, its Systems & Parts

- **Safety Features of Door System**

  - Transmission interlock prevent opening of doors whilst vehicle is in motion

- **Window Glasses**

  - Shatter proof glass should be used. When hit against any object the whole glass falls out and there will be no sharp edged pieces

Vehicle Body Engineering
Body & Safety Consideration

Vehicle Body Structure, its Systems & Parts

- **Window Glasses**

  - In bullet proof glass when hit there will be no normal angle of incident (inclination). The bullet is thrown out as there will always be some angle of incident.

- **Reliability / Safety Requirements Windscreen**

  - Freedom from faults which interfere with vision

Vehicle Body Engineering
Body & Safety Consideration

Vehicle Body Structure, its Systems & Parts

- **Reliability / Safety Requirements Windscreen**

  - High transparency & freedom from visual distortion

  - External durability to reduce surface degradation & scoring from wipers, ice scrapers, road grit, etc.

  - Vision not affected by normal road stone impacts

Vehicle Body Engineering

Body & Safety Consideration

Vehicle Body Structure, its Systems & Parts

- **Reliability / Safety Requirements Windscreen**

  - Retention of impacting occupant with low deceleration to avoid brain damage

  - Fragment formation should not expose the face & head to risk of severe laceration.

- **Bumper**

  - Shock absorbers behind the bumpers may be used. In some designs semi - circular

Vehicle Body Engineering
Body & Safety Consideration

Vehicle Body Structure, its Systems & Parts

- **Bumper**

  shape is adapted. This avoids direct collision and tilt of the vehicle.

  - Bumper design & height should be such that in case of accident it hits passenger below the knee. In this case the passenger will fall on to the vehicle otherwise on road which would be more dangerous.

Vehicle Body Engineering
Body & Safety Consideration

Vehicle Body Structure, its Systems & Parts

- **Seat - Back & Head Restraints**

  - Seat-backs should be in an upright position to get maximum protection from the seat belts

  - In reclined seat-back position the risk of sliding under the seat belt increases in a severe crash.

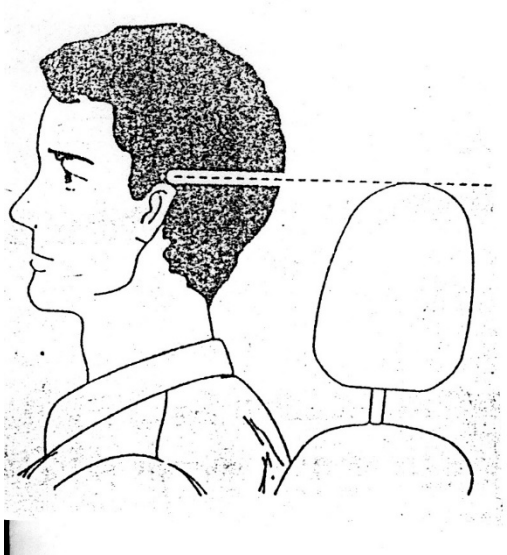
  - The front head restraints help from whiplash and other injures.

Vehicle Body Engineering
Body & Safety Consideration

Vehicle Body Structure, its Systems & Parts

- **Seat - Back & Head Restraints**

  - For most effectiveness, the Head Restraint should be adjusted such that the top of the restraint is even with the top of the ears as shown



Vehicle Body Engineering
Body & Safety Consideration

Vehicle Body Structure, its Systems & Parts

- **Ventilation**

  - Proper air vents directed towards the windscreen, side windows,passenger compartment, front and rear passenger foot walls should be provided.

- **Rear View Mirror**

  - Inside rear view mirror can be adjusted up, down or sideways to obtain the best view. Always adjust the mirror set to day positions

Vehicle Body Engineering
Body & Safety Consideration

Vehicle Body Structure, its Systems & Parts

- **Rear View Mirror**

  - Outside rear view mirror can be folded flat against the side of the vehicle and can be inclined at an angle to position it properly. The size or distance of a vehicle or object seen in an outside convex mirror look smaller and appear farther away as compared to a flat mirror.

Vehicle Body Engineering

Body & Safety Consideration

Safety Features Of Vehicles can be grouped as :

- **Additional Safety Features & Systems**
  - ➔ **ABS braking system**
  - ➔ **Seat belts**
  - ➔ **Air bags**
  - ➔ **Flashers & horns**
  - ➔ **Child safety**

Vehicle Body Engineering

Body & Safety Consideration

Additional Safety Features & Systems

- **ABS braking system**

  - The ABS braking system prevents the wheels from locking when braking

  - It makes the best road grip and provides safest control during emergency braking under difficult road conditions.

  - The driver can feel as ABS comes into play when the brake pedal pulsates slightly and the system gets noisier.

Vehicle Body Engineering

Body & Safety Consideration

Additional Safety Features & Systems

- **ABS braking system**

  - This indicates that the ABS is working and vehicle is travelling at the limit of the road grip, and the vehicle speed should be changed to fit the type of road surface.

  - The ABS is in addition, if failure occurs the basic braking system continue to work.

  - The advantage of the system is to give maximum maneuverability by preventing the

Vehicle Body Engineering

Body & Safety Consideration

Additional Safety Features & Systems

- **ABS braking system**

  the wheels from locking.

  - The light on the dash board warns driver to reduce speed.

Vehicle Body Engineering
Body & Safety Consideration

Additional Safety Features & Systems

- **Seat Belts**

  - Need & Requirements : Inside a moving car, if car suddenly stops, the occupant get hurled forward as the car has decelerated or stopped due to impact but occupant keep moving at about same speed as the car at the time of impact. So the body, particularly the head & chest smash into whatever is in front;windscreen,dash board, steering wheel

Vehicle Body Engineering

Body & Safety Consideration

Additional Safety Features & Systems

- **Seat Belts**

  Sometimes the occupant can be thrown out of the car through windscreen or opened door. It is not only the front seat passengers who are at risk but also the back seat passengers.

Seat Belts restrain occupant & holds back to the seat - preventing from hitting any hard structure in the car

Vehicle Body Engineering
Body & Safety Consideration

Additional Safety Features & Systems

- **Seat Belts**

  - Construction : Seat belt comprise of a lap band and shoulder band held in place by single buckle, and bolts fastened to the car body.

  - Types : Seat belts are of two types ; non-retracting and automatic-retraction. First type do not adjust to wearer's movement & not convenient. The second type allows to

Vehicle Body Engineering
Body & Safety Consideration

Additional Safety Features & Systems

- **Seat Belts**

  move around freely. It has mechanism that restrains the occupant when car hits or stops suddenly.

  - Precautions to be observed : Seat belts are designed to bear upon the bony structure of the body, and should be worn low across the front of the pelvis, chest, and shoulders. Seat belts should be adjusted as firmly as

Vehicle Body Engineering
Body & Safety Consideration

Additional Safety Features & Systems

- **Seat Belts**

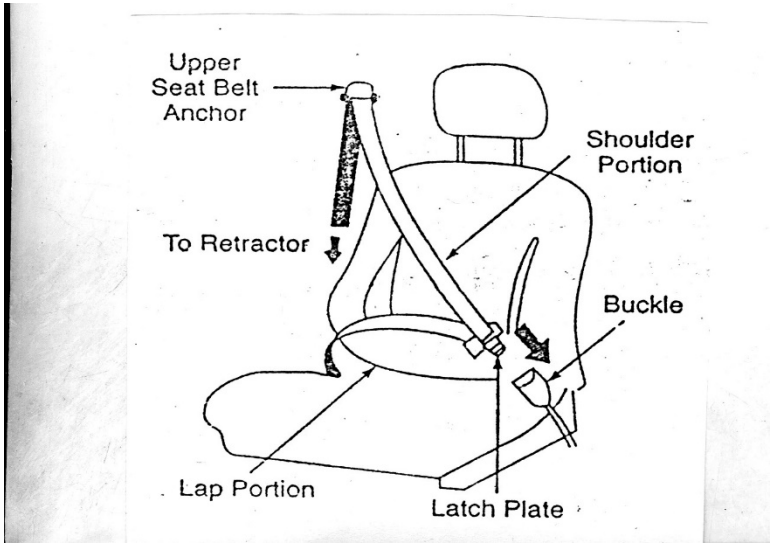
  possible. Belt should not be worn with straps twisted. It is dangerous to put belt around a child being carried on the occupant's lap.

- **Working of the Seat Belt System :**

  - Lap/Shoulder Belt has a single belt that goes over the shoulder, across chest, and across pelvis as shown in figure.

Vehicle Body Engineering
Body & Safety Consideration

Additional Safety Features & Systems



- In normal driving, the belt fitted with a locking retractor allows occupant move freely in the seat while keeps tension on the belt. During a collision or sudden stop the retractor automatically locks the belt to help

Vehicle Body Engineering
Body & Safety Consideration

restrain body.

- Before putting on the seat belt move seat as far back as possible,seat back to be up upright and there should be no twists in the belt.

- **Air Bag**

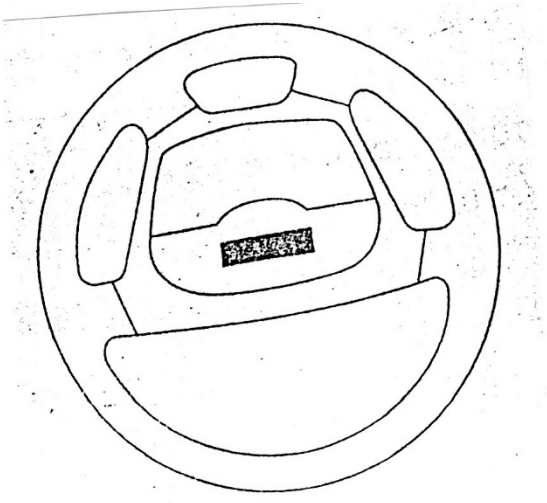
-Air bag is a safety device that protects the driver & the front seat passenger during head-on collision

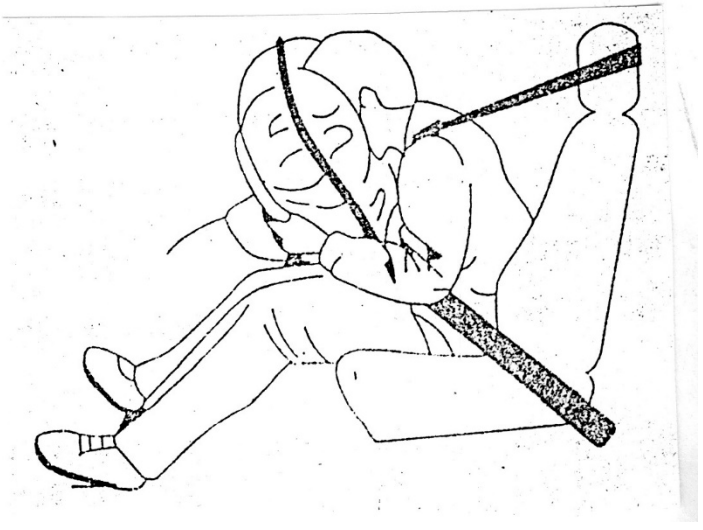
- Air bag is an instantly inflatable cushion stored in the center pad of steering wheel and in the dash board on passenger side

Vehicle Body Engineering

Body & Safety Consideration

Additional Safety Features & Systems





- In case of a collision of magnitude exceeding the set value, the sensor activates the mechanism and cushion inflates instantly to act as a soft protecting barrier

Vehicle Body Engineering
Body & Safety Consideration

Additional Safety Features & Systems

- Air bag inflates with considerable force & speed (with in milliseconds). After inflating completely it deflates immediately not to interfere with driver's visibility or ability to steer and operate controls.

- When air bag inflates, an operating noise may be heard and a small amount of smoke-like gas or dust is released which is harmless.

- Air bag system will not be triggered in the event of rear or side impacts, rollovers or minor frontal collisions. It is triggered only once & then replaced.

Vehicle Body Engineering
Body & Safety Consideration

Additional Safety Features & Systems

- **Hertomatic Flashers and Horn (beep noise)**

  operate for every one minute, if not attended then ultimately the ignition will be automatically switched off.

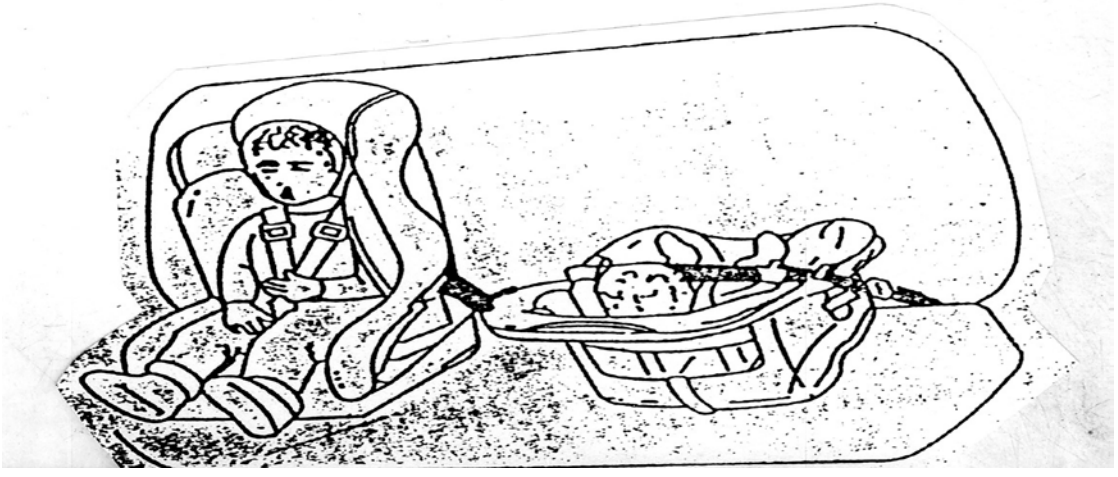
- **Child Safety**

  - Infants and young children should always be properly restrained whenever they ride in a car as shown

Vehicle Body Engineering

Body & Safety Consideration

Additional Safety Features & Systems



Children should ride in rear seat and not in lap of adults. Place the child restraint in the seat with a lap/ shoulder belt through the restraint (infants & toddler seat). Use child proof door locks

Vehicle Body Engineering

Body & Safety Consideration

- **General & other safety recommendations**
  - ➔ There should be no loose items inside vehicle which could be thrown around and may hurt during accident or sudden braking / stops
  - ➔ Luggage should be securely stored or tied downed
  - ➔ Seats should be upright, head restrain adjusted, & seat belts fastened
  - ➔ Vehicle operation control should not be obstructed
  - ➔ First-Aid kits should be available

Vehicle Body Engineering

Body & Safety Consideration

- **General & other safety recommendations**
  - ➔ **Driver should not be under the influence of alcohol or drugs**
  - ➔ **Ensure all doors are properly closed**
  - ➔ **Ensure buckling up of children and child constraint system is properly installed**

Vehicle Body Engineering

Car Body Construction

Vehicle Body Engineering

Car Body Construction

Identification & Functions of Body Pressings

- In a separate body and chassis construction :
  - Chassis resists bending & twisting loads
  - Body provides only functional needs

- Separate body & chassis type of construction is being superseded by the integral or mono-construction system

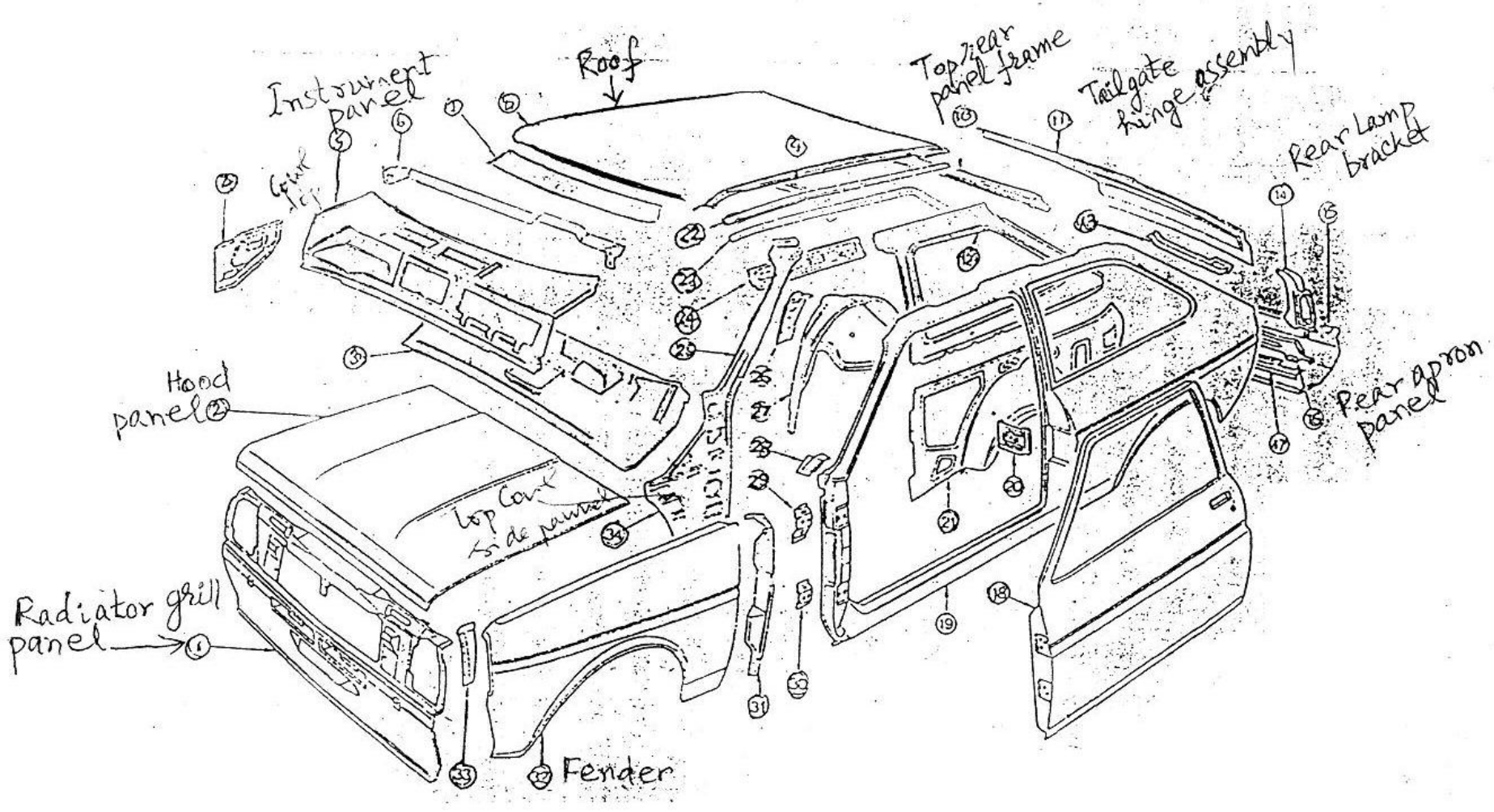
- In integral construction the frame members become an integral part of the body

Vehicle Body Engineering

Car Body Construction

Identification & Functions of Body Pressings

- **Car Body Assemblies**

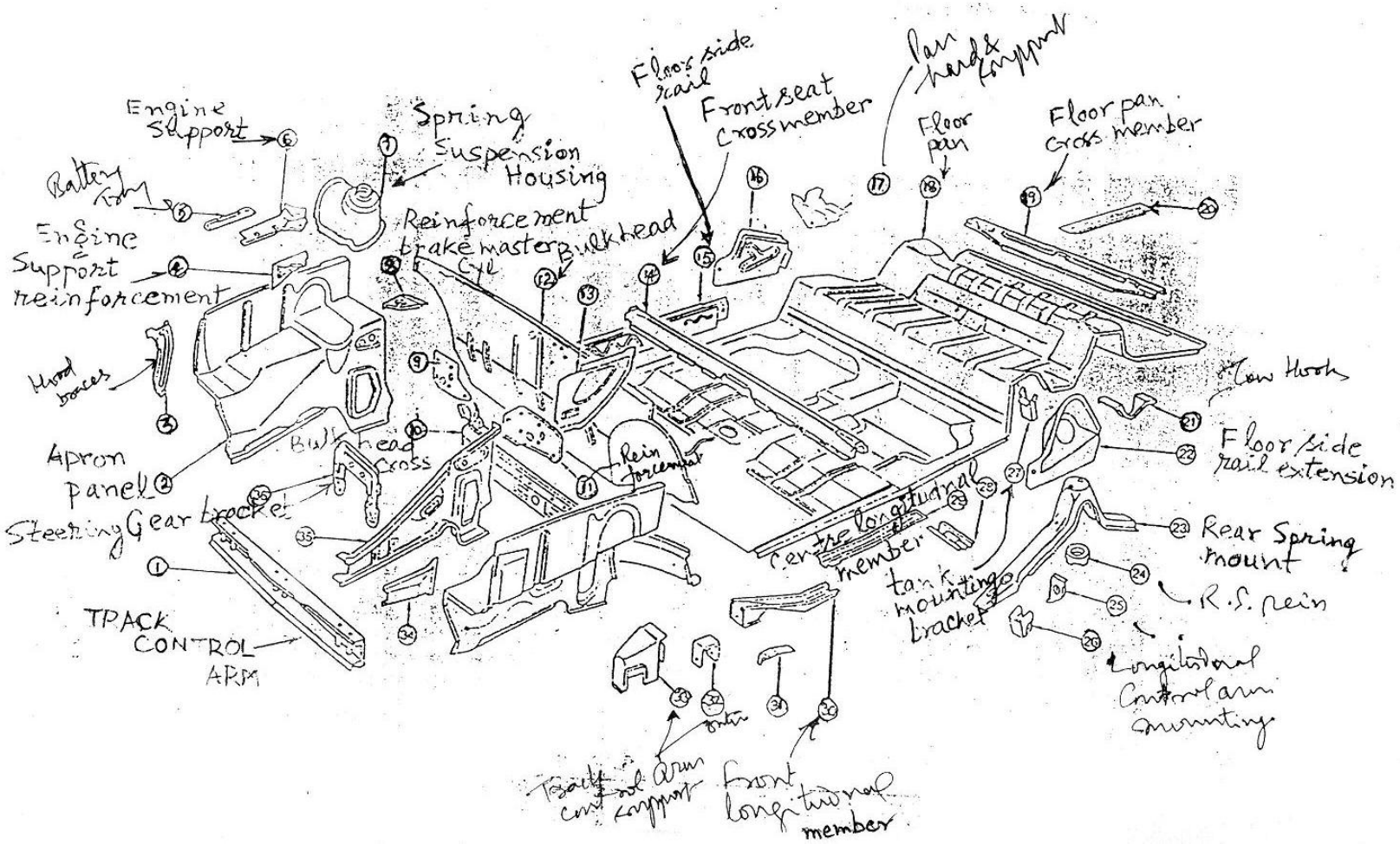


Vehicle Body Engineering

Car Body Construction

Identification & Functions of Body Pressings

- **Car Underbody Assemblies**



Vehicle Body Engineering

Car Body Construction

Identification & Functions of Body Pressings

- Box sectioning of the body sills, door pillars and roof reinforcements form a framed structure in which stresses are distributed to all parts of the body
- In reinforced body shell buckling is prevented by use of curved plates with multiple radii (or crown). A flat plate offer little resistance to buckling.
- For stress carrying parts of body shell greater rigidity can be achieved by using ‘ top of hat ‘ section or channel & angles built into the assembly
- This is also convenient for construction of streamlined shapes for minimum aerodynamic resistance's

Vehicle Body Engineering

Car Body Construction

Identification & Functions of Body Pressings

- Mass production of car bodies in steel consists of manufacturing of sub-assemblies like floor-pan, two sides, roof cross-member,etc. assembled together and spot-welded to form a complete body shell
- For construction of a typical Car Body Shell various sub-assemblies generally required are described in order to understand a sequence of its construction .

Vehicle Body Engineering

Car Body Construction

Sub- Assemblies & Construction of Body Shell

Various sub-assemblies are :

- Underbody assembly
- Body side assembly
- Shroud and dash panel assembly
- Roof & back window aperture panels
- The Center pillar (B- C post)
- Rear Bulk-head and parcel shelf
- Front end work
- Front wings
- Door panel assembly

Vehicle Body Engineering

Car Body Construction

Sub- Assemblies & Construction of Body Shell

Various sub-assemblies are :

- **Bonnet panel assembly**
- **Boot lid assembly**

- **Under body assembly**

  - This positions the engine, transmission, wheel-arches, seats, etc.

  - Body sills provide longitudinal edge reinforcements

  - The floor pan strengthened by; box members at right angles to the transmission tunnel; all cross members

Vehicle Body Engineering

Car Body Construction

Sub- Assemblies & Construction of Body Shell

- **Under body assembly**

  at the rear,front of the front seats, front of the rear seats, etc. joined together provide lateral reinforcements

  - The transmission tunnel, which acts like an inverted channel section provide central strength built into the floor

  - The remaining area of flat metal is ribbed or dished below the seats and in the foot wells to add stiffness to the sub-assembly

Vehicle Body Engineering

Car Body Construction

Sub- Assemblies & Construction of Body Shell

- **Body side assembly**

  - The side frames reinforcing the floor pan, body sills also transmit loads between them

  - The center pillars are welded in between the body sill and the roof / cant rails.

  - These are usually assembled as a box section using a ‘top-hat’ section and flat plate, with the flanges forming attachments for the door, weather seals, etc.

  - The front hinge pillars extend forward to join with the dash panel, front bulkhead cross member. This provides strength by ‘boxing’ the front end.

Vehicle Body Engineering

Car Body Construction

Sub- Assemblies & Construction of Body Shell

- **Shroud & Dash panel assembly**

  - These assemblies are complex structures connecting the two body sides across the car

  - The complete assembly is also called the firewall because it is the partition between the passenger and engine compartment, and carries part of the forces set up by the front suspension, weight of the power unit.

  - The heating / cooling systems & its distribution chamber, instrument panel & its necessary controls, wiring, tubing, etc., the steering column are all attached to the front bulk head of the body and is

Vehicle Body Engineering

Car Body Construction

Sub- Assemblies & Construction of Body Shell

- **Shroud & Dash panel assembly**

  usually formed by assembling together several smaller panels (dash & shroud) which are joined by welds to form an integral unit.

  - The instrument panel connected to the cowl panel provides mountings for instruments.

  - In some cases the wind screen opening is connected to the cowl panel. In this case the windscreen pillars, the narrow sloping construction at either side of the windscreen opening are part of the cowl. Upper edge of the cowl panel forms the front edge of the roof panel

Vehicle Body Engineering

Car Body Construction

Sub- Assemblies & Construction of Body Shell

- **Shroud & Dash panel assembly**

  - On many passenger cars the front door hinge pillar is also an integral part of the cowl

- **Roof & back window aperture panels**

  - Roof panel is one of the largest of all major body panels and it is one of the simplest in construction.

  - Usually it is all-steel, one piece construction.

  - On some cars it ends at the windscreen on front side & rear window on the rear side. It may extend down -

Vehicle Body Engineering

Car Body Construction

Sub- Assemblies & Construction of Body Shell

- Roof & back window aperture panels

wards around windscreen on front side and on rear side the rear window opening is in the lower rear roof and forming the top panel around the rear boot opening

- The roof and its reinforcing members form lid of the box structure.

- The stiffness is built by the curvature given to it, the reinforcement consisting of small metal strips placed crosswise to the roof at intervals along the inside surface. These also provide tacking strips for securing

Vehicle Body Engineering

Car Body Construction

Sub- Assemblies & Construction of Body Shell

- Roof & back window aperture panels

  the heal lining & inside trims in place . In some cases the roof panel is also ribbed or dished longitudinally.

- The Center Pillar (B - C post)

  - It acts as central roof and side support between the front and rear of the car body side structure.

  - Its construction must be exceptionally strong as it is the shut (lock) pillar and the hinge pillar for the doors.

  - The center pillar is irregular in shape since it must conform to outside contours of the door as well as

Vehicle Body Engineering

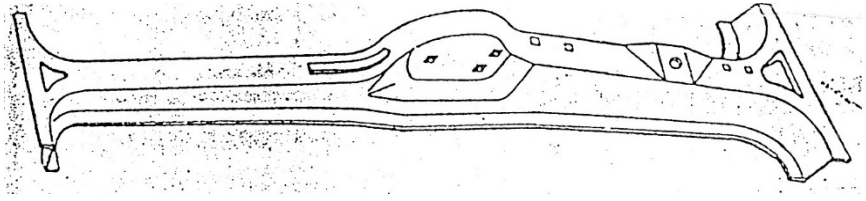
Car Body Construction

Sub- Assemblies & Construction of Body Shell

The Center Pillar (B - C post)

accommodate door lock, striker plate, hinges,etc.

depending on the body style.



Vehicle Body Engineering

Car Body Construction

Sub- Assemblies & Construction of Body Shell

- **Rear Bulk - Head and Parcel Shelf**

  - This provides transverse stiffness and is welded between the body side frames and rear seat frame. In construction they are often pierced and flanged to increase rigidity.

  - The rear panel is curved to form part of the external shape of the body with its upper edge providing support to the boot lid seal.

- **Front End Work**

  -The front end carries the engine and front suspension, steering gear and radiator.

Vehicle Body Engineering

Car Body Construction

Sub- Assemblies & Construction of Body Shell

- **Front End Work**

  - The suspension system may affect detail design of the panels but the loads must be transmitted to the wings and/or wheel arches and on into the body panels

  - The front cross- member assembly braces the front of the car and carries the radiator, headlamps, etc. The side assemblies and front wheelhouse panel assembly form a housing for the wheel, a mating edge for the bonnet and a strong box section for attachment to the side frames and front bulkhead.

Vehicle Body Engineering

Car Body Construction

Sub- Assemblies & Construction of Body Shell

- **Front Wings**

  - The front wings are each attached to the inner construction of the car body by means of a flange along the length of the wing, which is turned inwards from the outside surface and through which securing bolts can pass.

  - To add strength and to prevent vibration the wing brackets are sometimes fitted.

  - The unsupported edges are swaged and turned inwards to give strength& cracks developing in the edges of the wings due to vibrations. This provides

Vehicle Body Engineering

Car Body Construction

Sub- Assemblies & Construction of Body Shell

- **Front Wings**

  a smooth finished appearance to the edges of the wings.

  - Apart from covering the suspension & wheel the wings prevent water and mud, etc. being thrown up onto the body by the wheels.

- **Door Panel Assembly**

  - The door is composed of two main panels; outer and inner panel, constructed to act as a frame for the door.

  - The outer panel flanges over the inner panel around the edges to form a single unit.

Vehicle Body Engineering

Car Body Construction

Sub- Assemblies & Construction of Body Shell

- **Door Panel Assembly**

  - The window channel may be welded or bolted to inner door panel to provide support & direction to the window glass.

  - The inner panel has holes or apertures drilled, punched or formed for attachment of door trims.

  - The thickness of the door is due to the depth of the inner panel which accommodate door catch,window mechanism,etc.

  - The inner panel forms the lock pillar and the hinge pillar sections of the door.

Vehicle Body Engineering

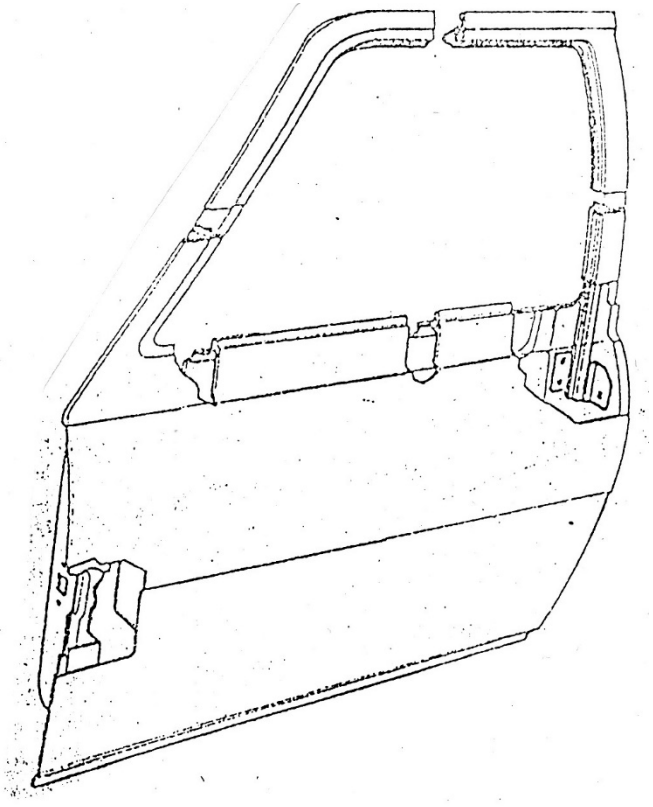
Car Body Construction

Sub- Assemblies & Construction of Body Shell

- **Door Panel Assembly**

  - Small reinforcement angles are usually used between the outer and inner panels where lock is inserted through the door and the hinges are attached.

  - The outer panel is provided with an opening through which outside door handle protrudes.



Vehicle Body Engineering

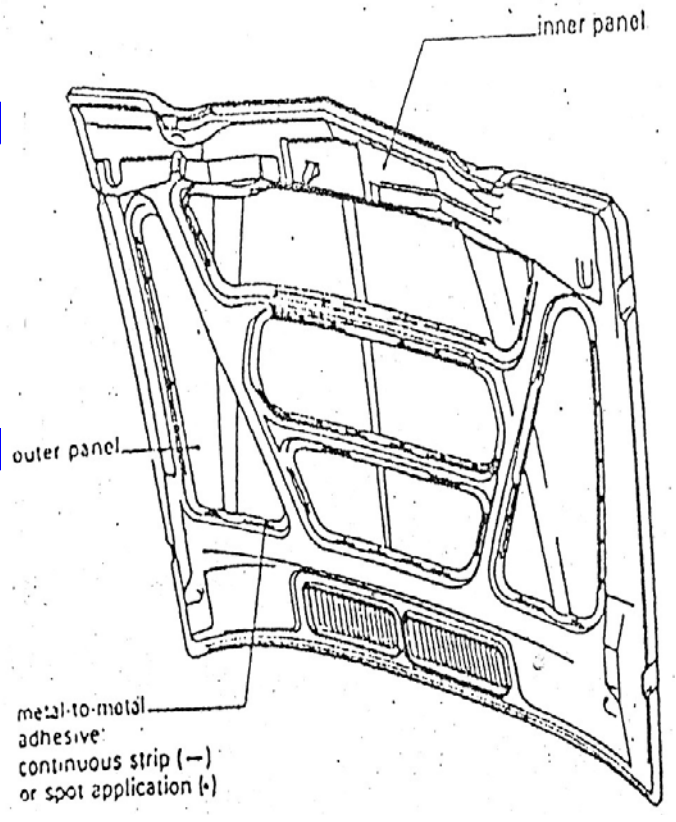
Car Body Construction

Sub- Assemblies & Construction of Body Shell

- **Bonnet Assembly**

  - The bonnet is the panel covering the engine compartment.

  - Most one-piece bonnets are hinged at the rear so that the front end swings up when opened. The catches are at front and in most cases controlled from inside the car.



Vehicle Body Engineering

Car Body Construction

Sub- Assemblies & Construction of Body Shell

- **Bonnet Panel Assembly**

  - One-piece bonnets are quite large and, to make opening easier, the hinges are usually counter - balanced by means of tension or torsion springs.

  - Smaller bonnets are held in place by a stay

  - The bonnet consists of the outer panel and inner reinforcement constructed in the 'H' or cruciform pattern. The reinforcement is basically a top-hat section to give rigidity to the component.

  - The main strength of the bonnet lies in the fact that the inner construction acts like a frame and the outer

Vehicle Body Engineering

Car Body Construction

Sub- Assemblies & Construction of Body Shell

panel is formed round its edges, acting as flanges

- **Boot Lid Assembly**

  - The boot lid is composed of an inner and an outer panel spot-welded together along their flanged edges to form a single unit .

  - Both type of hinges ; external & concealed are used.

  - A catch is provided at the bottom rear of the boot lid and controlled by an external handle. In some models handles are not provided. The hinges are spring loaded so that lid rises automatically by the hinge mechanism for opening & holding it in place.

Vehicle Body Engineering

Car Body Construction

Body Build, Paint and Sealing

- **Body build**

  - A car body is made up of six major units ; Floor, Two sides, Front end, Rear end, Roof

  - These major units themselves made up from numerous smaller pressings reach main body-build conveyors as sub- assemblies

  - Special jigs carry the body floor assembly, pairs of side frames, front & rear sections mate up with the trucks so that all the units are clamped securely together while the welding is done. The roof is the last major section to go on.

Vehicle Body Engineering

Car Body Construction

Body Build, Paint and Sealing

- **Body build**

  - Various forms of welding are used in building up a car body shell like spot- welding, seam welding, etc.

  - After welding, every joint is sealed with special compounds to make it a watertight car body.

  - After the body shells have assembled their doors, bonnet panels, boot lids, etc. they are prepared for the paint shop.

  - Panel surfaces are inspected and blemishes in the sheet metal are removed with portable sanding machines

Vehicle Body Engineering

Car Body Construction

Body Build, Paint and Sealing

- **Painting**

  - The painting of a car body means protection of sheet metal, inside and out, underneath as well as on top besides giving them a coat of bright shiny colour.

  - The first stage is a multi-part rust-proofing treatment by complete immersion of the body shell in a huge bath of anti-rust alkyd primer.

  - This is followed by surface priming. The entire under body,wheel arches, insides of the body sills,etc. are treated with multi-coats of epoxy primer followed by baking in huge high- temperature ovens.

Vehicle Body Engineering

Car Body Construction

Body Build, Paint and Sealing

- **Painting**

  - The under body areas are coated with thick layers of bituminous or polymer compounds for anti-corrosion protection. This also helps reduce road noise.

  - In final stage the complete body is given a base coat of acrylic paint with special adhesion qualities. This is followed by multi-coats of the finish colour paint which is basked in hot oven to create a hard, deep-gloss finish.

  - In between these operations rubbing, washing, cleaning, etc are carried out .

Vehicle Body Engineering

Car Body Construction

Body Build, Paint and Sealing

- **Sealing**

- The entire car body is vulnerable to the entry of water, fumes, and dust.

- The various locations on the vehicle body that require some form of seal are ;

1. Areas where a permanently flexible seal is required, e.g. windscreen, rear screen

2. External panel seams.

3. Areas where a seal is required to withstand stone pecking, e.g. wheel arches, floor pan

4. Protected areas where a bulk sealer is required

Vehicle Body Engineering

Car Body Construction

Body Build, Paint and Sealing

- **Sealing**

  - It is essential for the various sealing materials (caulking cmpound, multi- purpose adhesive, metal joint sealer, windshield sealer, double-sided adhesive tape, PVC foil, etc.) to be applied to clean dry surface if they are to adhere and form an effective seal.

- **Fixtures and fittings**

  - From paint shop the car body pass into the trim shop for ‘furnishing’ where various items like carpets, seats, door handles, window glass, chrome moldings, electric wiring, steering wheel,fascia panels,instrument

Vehicle Body Engineering

Car Body Construction

Body Build, Paint and Sealing

- Fixtures and fittings

clusters, etc. are fitted

- Midway through this long furnishing the body pass through a long water tunnel where it is drenched by powerful jets of water. This water contains a fluorescent dye and any drop of water that may have found its way into the body can be detected.

- Before the bodies leave the trim-shop some minor mechanical units are added and transferred to the ‘body drop’.

Vehicle Body Engineering

Aerodynamics

Dr. Mukesh Saxena

Vehicle Body Engineering

Aerodynamics

Introduction :

- **The power delivered by the engine is finally made available at the drive wheels as propulsive force.**
- **The propulsive force or tractive effort, available at the contact between the driving wheels and road should be more than the total resistance for the motion of a vehicle**
- **The surplus tractive effort contribute for acceleration, climbing gradient, etc.**
- **The total resistance to the motion of a vehicle**

Vehicle Body Engineering

Aerodynamics

Introduction :

is by Air resistance & Rolling resistance

- **The vehicle drag is a force which resists motion and is due to ;**

  a) the deformation of the wheel and the ground

  b) aerodynamic effects of air flow over the vehicle

- **Deformation of the wheel**

  - the pneumatic tyres are most suitable for road transport vehicles.

  - the deformation of tyres account for 90 to 95 % of the rolling resistance of the vehicle

Vehicle Body Engineering

Aerodynamics

Introduction :

- the distortion of the tyre tread as it passes through the contact area results in a hysteresses loss manifests itself as heat & rise in temperature of tyre

- The hysteresses loss is primarily a function of deflection caused by the load it carries

- Other parameters affecting rolling resistance are; tyre temp., inflation pressure, tread thickness, no. of plies, rubber quality, level of torque transmitted and vehicle speed

Vehicle Body Engineering

Aerodynamics

Introduction :

- The Rolling resistance expressed in terms of non- dimensional rolling coefficient,α as

$R_r = \alpha \cdot W$ where; W - weight of vehicle

- The relationship between rolling resistance and vehicle weight is more complex and require a detailed knowledge of the soil and ground material,etc.

Vehicle Body Engineering

Aerodynamics

Introduction :

- **Aerodynamic effects of air flow over the vehicle**

- A moving vehicle, in displacing the surrounding air, has a resultant resisting force called aerodynamic drag or simply air resistance.

- It can be expressed as resistive force opposing the motion of a vehicle through the air and the work done in overcoming the force is dissipated as energy lost to the air flow.

- The amount of drag depends on the vehicle shape and varies with the speed of the vehicle.

Vehicle Body Engineering

Aerodynamics

Introduction :

- **Aerodynamic effects of air flow over the vehicle**

- A low-drag body allows vehicle to reach higher speeds for a given power out put.Conversely, reducing the power consumption at any particular speed makes it available for acceleration.

- Reducing power requirement improves fuel consumption thereby reducing on-board fuel carrying requirements. This can contribute towards reducing laden weight of the vehicle

Vehicle Body Engineering

Aerodynamics

Introduction :

- **Aerodynamic effects of air flow over the vehicle**

- Motor vehicles have demonstrated strong aerodynamic influence upon their design.

- Until recently flowing lines on vehicle body were primarily a statement of style and fashion with little regard for economic / environmental benefits.

- Rising fuel prices, triggered by fuel crisis in 1970s and now the environmental concerns have provided serious attention towards aerodynamic designs.

Vehicle Body Engineering

Aerodynamics

Introduction :

- **Aerodynamic effects of air flow over the vehicle**

  - Aerodynamic research focused upon ;

  drag reduction : for fuel efficiency & emission

  lift & side forces : vehicle stability

  low drag shapes reduce stability when driven in cross-wind conditions

  - Understanding of Aerodynamics of vehicle is highly complex as unsteady flows are associated with it.

  - Experimental and Computational flow prediction methods still require substantial developments

Vehicle Body Engineering

Aerodynamics

Introduction :

- **Aerodynamic effects of air flow over the vehicle**

- Significance of Aerodynamic Study

1. Reduction of drag force and achieve maximum speed & acceleration for the same power out put

2. Reduction of drag force improves fuel economy

3. Good aerodynamic design gives better appearance and styling

4. Good stability and safety can be provided by reducing various forces and moments subjected to by the vehicle

Vehicle Body Engineering

Aerodynamics

Introduction :

- **Aerodynamic effects of air flow over the vehicle**

- Significance of Aerodynamic Study

5. This helps to understand the dirt flow,exhaust gas flow patterns, etc.

6. Good aerodynamic design provide proper ventilation, reduce noise,etc.

Vehicle Body Engineering

Aerodynamics

Introduction :

- **Aerodynamic effects of air flow over the vehicle**

- The composition of Aerodynamic drag is due to

I) The air flow in the boundary layer resulting in the loss of momentum of the main stream and is called 'skin friction drag'.

- A component from the downstream of the trailing vortices behind the vehicle is called 'Induced drag'

- The 'normal pressure drag' is found out by integration of the product (normal pressure x area) around the vehicle. This produces net force

Vehicle Body Engineering

Aerodynamics

Introduction :

- **Aerodynamic effects of air flow over the vehicle opposing the motion of the vehicle because separation of flow at rear of the vehicle results in lowering of pressure on rearward facing surfaces.**

  - The skin friction drag and the induced drag are usually small in comparison to normal pressure drag.

Vehicle Body Engineering

Aerodynamics

Aerodynamic Forces and Moments :

- **The profile of the vehicle is the principle component of aerodynamic drag and is governed by the way in which vehicle disturbs the air stream.**
- **Its behavior has been found not to accord with established aerodynamic theory evolved in aviation since vehicle has to maintain contact with the ground.**
- **The importance of a good aerodynamic parameters in the design of a vehicle is being increasingly recognized. The designer must have a knowledge of the forces and the laws governing them in order to**

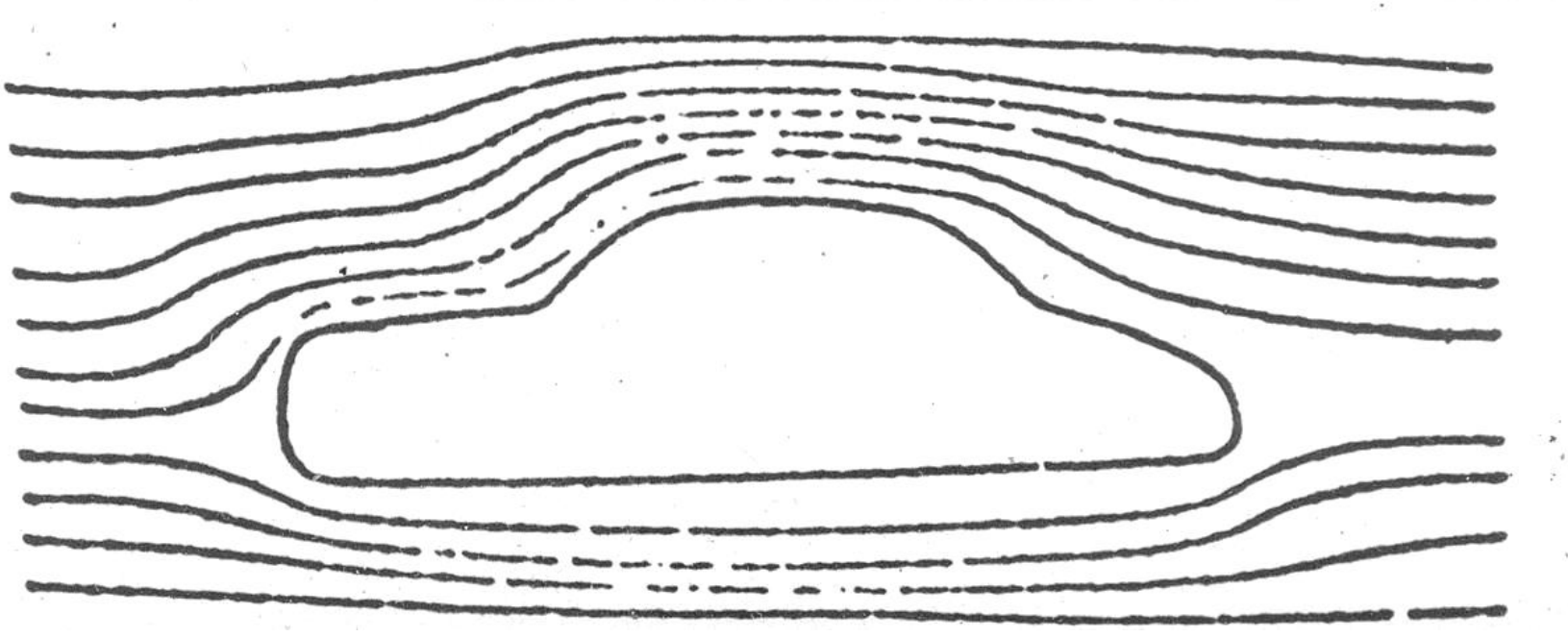
Vehicle Body Engineering

Aerodynamics

Aerodynamic Forces and Moments :

produce body shapes which will have acceptable aerodynamic characteristics.

- **Considering a car profile as an aerofoil the streamlines around a car body is as shown below**



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Aerodynamics

Aerodynamic Forces and Moments :

- **The car body profile shown having smooth streamlines which are continuous and with no separation of boundary layers & vortices. However, like an aerofoil, the streamlines over the upper part have a higher velocity than the streamlines below the car.**
- **For complete description of aerodynamic effects on the motion of the vehicle it should be considered as a mass having six degree of freedom and the aerodynamic forces and moments acting on the vehicle are balanced by the wheel reactions.**

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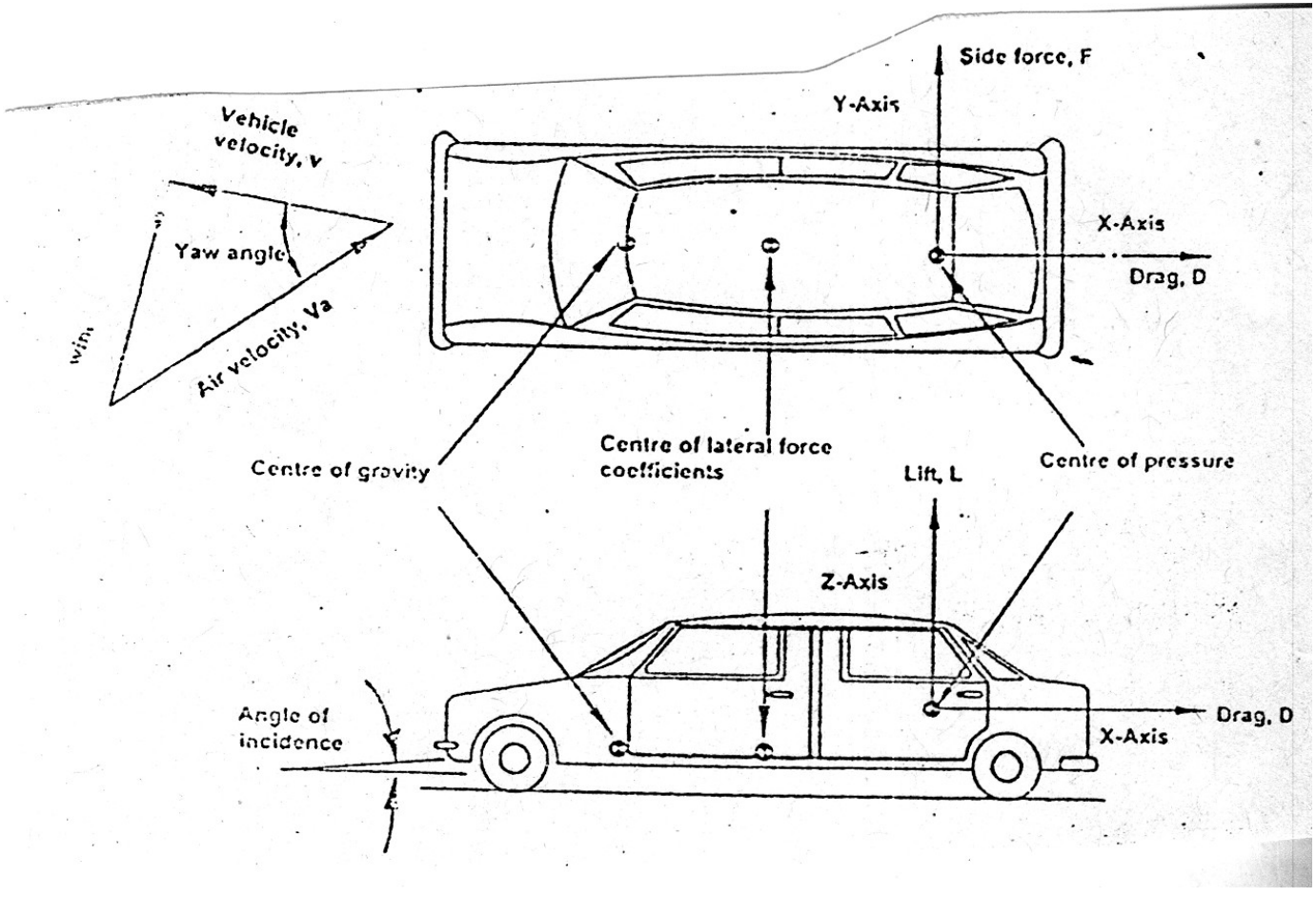
Aerodynamics

Aerodynamic Forces and Moments :

- **The aerodynamic forces on a vehicle in a real environment is as shown below**



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Aerodynamics

Aerodynamic Forces and Moments :

- **The aerodynamic forces on a vehicle act at the Center of Pressure and summarized as follows**

  - Px : force of air drag in the direction of motion (longitudinal)

  - Py : side forces or cross wind forces (lateral)

  - Pz : aerodynamic lift forces (vertical)

- **As these forces are not acting at center of gravity, they cause moments as follows**

  - Mx : rolling moment caused by force,Py about the X-axis

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Aerodynamics

Aerodynamic Forces and Moments :

- My : Pitching moment caused by forces about the Y-axis
- Mz : Yawing moment caused by the force, Py about the Z - axis

- Drag force, Px

  - The air flow over a vehicle is complex and the aerodynamic drag is expressed by the semi - empirical equation to represent the aerodynamic effect. It is defined by the following equation.

Vehicle Body Engineering

Aerodynamics

Aerodynamic Forces and Moments :

$$DA = 1/2\ \rho\ V^2\ A\ Cd$$

where ; DA = aerodynamic drag force (Px) , Kgf

ρ = air density , Kgf. Sec^2 / m^4

V = velocity , m / sec

A = Frontal area of the vehicle , m^2

Cd = aerodynamic drag coefficient

- Lift force, Pz

  The lift force is a result of the asymmetrical flow of air above and below the vehicle. The lift force

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Aerodynamics

Aerodynamic Forces and Moments :

affects the vehicle driving stability. The lift force is measured at the centerline of the vehicle at the center of the wheel base.

$$Pz = 1/2\ \rho\ V^2\ A\ Cz \quad , Kgf$$

where ; Cz = Lift coefficient

- Side Force, Py

The side force is formed by the asymmetric flow of air around the body of the vehicle due to cross wind flow (forces). The lateral wind components impose a side force on the vehicle to change its direction .

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Aerodynamics

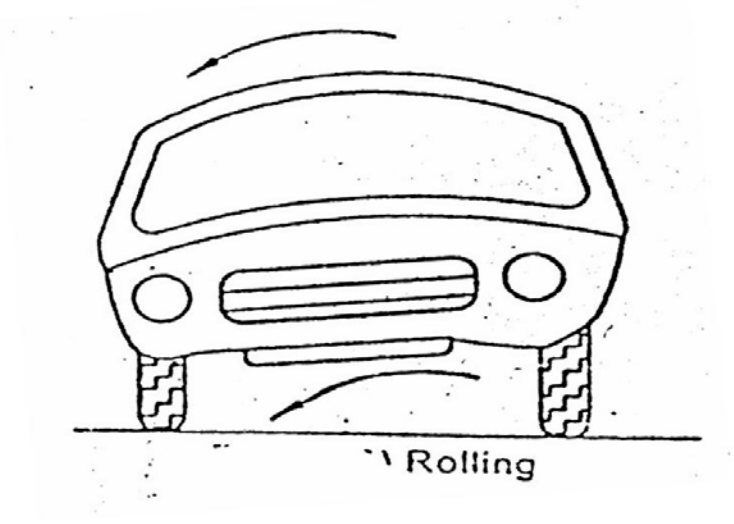
Aerodynamic Forces and Moments :

Side force acts on the body at the center of pressure

$$Py = 1/2\ \rho\ V^2\ A\ Cy \quad , Kgf$$

where ; Cy = cross wind force coefficient

- Rolling : The angular oscillation of the vehicle about longitudinal axis is called rolling as shown



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Aerodynamics

Aerodynamic Forces and Moments :

- Rolling Moment :

The rolling moment acts about the longitudinal (horizontal) axis and is produced by the side wind forces. It has only minor influence on vehicle stability depending on the suspension system.

$$RM = 1/2 \ \rho \ V^2 \ A \ C_{RM} \ . \ L \quad , Kgf.m$$

where ;

C_{RM} = rolling moment coefficient

L = wheel base

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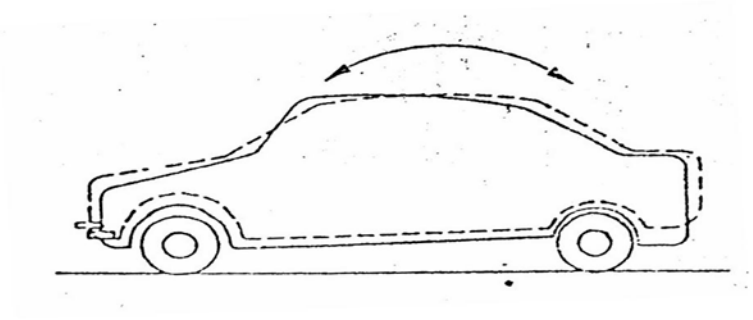
Aerodynamics

Aerodynamic Forces and Moments :

- **Pitching :**

The angular oscillation of the vehicle about lateral (horizontal) axis is called pitching as shown



- **Pitching Moments**

Pitching moment acts to transfer weight between the front and rear axles. The pitching moment is

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Aerodynamics

Aerodynamic Forces and Moments :

usually negative i.e., nose down. This makes the rear axle lift off the ground and further reduce the available traction. The pitching moment arises from the drag but drag itself does not act at the ground plane. The lifting force may not act exactly at the center of the wheel base.

$$PM = 1/2 \ \rho \ V^2 \ A \ C_{pm} \ . \ L \qquad , Kgf.m$$

where ;

C_{pm} = pitching moment coefficient

L = wheel base or characteristic length, m

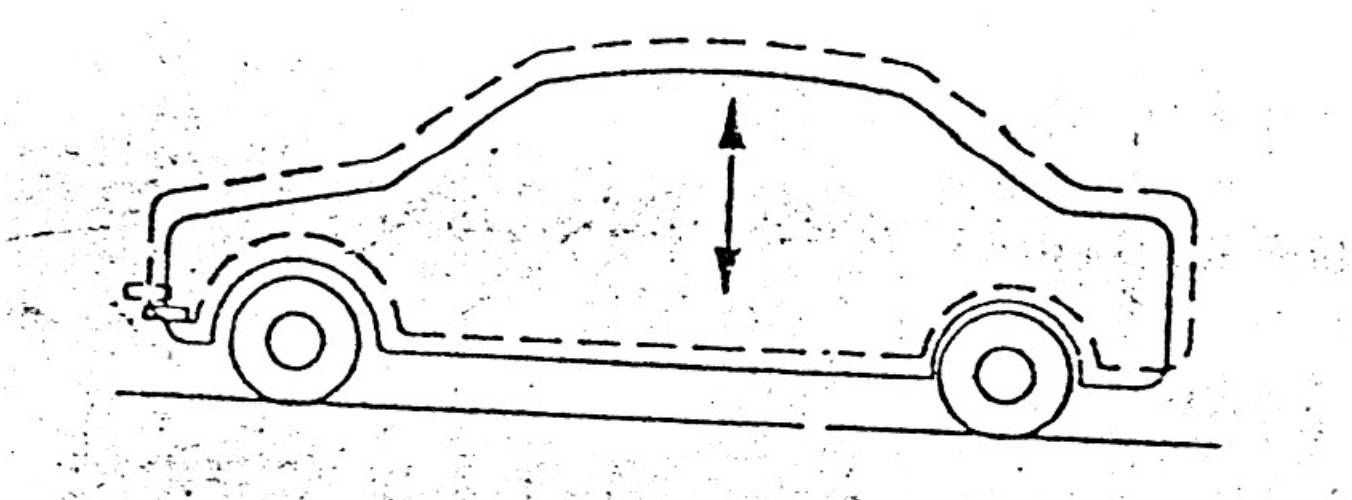
Vehicle Body Engineering

Aerodynamics

Aerodynamic Forces and Moments :

- Yawing

The angular oscillation of the vehicle about the vertical axis is called yawing. It is the vertical movement of the complete vehicle body. So the complete body rises up and down and know as bouncing as shown in the figure below



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Aerodynamics

Aerodynamic Forces and Moments :

- Yawing Moment

The lateral force caused by a side wind does not act at the mid- wheel base position. A side wind will produce a Yawing moment tending to turn the vehicle away from the direction of motion. Yawing moment is defined as

$$YM = 1/2 \ \rho \ V^2 \ A \ C_{ym} \ . \ L \qquad , \text{Kgf.m}$$

where ;

C_{ym} = Yawing moment coefficient

L = wheel base or characteristic length, m

Vehicle Body Engineering

Aerodynamics

Aerodynamic Drag : types & effects

The total aerodynamic drag of a vehicle includes many factors which offer overall air resistance to the motion of vehicle. The types of aerodynamic drag components and their approximate relative contributions are ;

Profile or Form Drag	55 - 60 %
Induced or Lift Drag	~ 8 %
Surface or Friction Drag	~ 10 %
Interference	~ 15 %
Cooling & Ventilation System Drag	~ 10 %
Rotating Wheel & other	~ 1 %

Vehicle Body Engineering

Aerodynamics

Aerodynamic Drag : types & effects

- **Profile or Form Drag**

  The profile drag depends upon the longitudinal section of the vehicle body , and plays the most important part as its contribution is the maximum.

  A careful choice of body profile, essential for low drag, requires streamlines to becontinuous and separation of boundary layers with its attendant vortices to be avoided.

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Aerodynamics

Aerodynamic Drag : types & effects

- **Induced or Lift Drag**

  A vehicle body produces accelerated air flow and the induced drag is caused by the vortices formed at the sides of the vehicle travelling downwards.

  The pressure differential from the top to the bottom of the vehicle causes a lift drag.

  This lift force depends on the upper surfaces especially in areas of the leading edge of the hood, wind shield corners, leading edges of the cowl and underbody such as suspension, exhaust system &other components protruding, and the ground

Vehicle Body Engineering

Aerodynamics

Aerodynamic Drag : types & effects

- **Induced or Lift Drag**

  clearance. Lift is not a serious problem at normal speeds but at very high speeds it can affect stability and braking performance of the vehicle.

  The lift tends to reduce pressure between ground and wheels. This causes loss of steering control on the front axle and loss of traction on the rear axle.

- **Surface Drag**

  The surface or friction drag contribute substantially.

  It is due to the friction of the layers of air passing

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Aerodynamics

Aerodynamic Drag : types & effects

over the outside surface of the vehicle body. The friction losses on the boundary layer and the surface roughness has considerable effect on surface drag. If this surface is kept smooth, a laminar boundary layer will be maintained further along the vehicle than with the rough surface.

- **Interference Drag**

  This type of drag contribute significantly. This is due to air flow over the many exterior components of the vehicle body and also due to its interactions with the air flow over the basic body shape.

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Aerodynamics

Aerodynamic Drag : types & effects

Exterior vehicle body projections such as door handles, mirrors,roof luggage, wind shield wipers,

etc. and also, projections below the vehicle such as axles, tow-bars,etc. contribute to interference drag

- Cooling & ventilation system drag

  The cooling and ventilation systems also contribute significantly to the total drag. Air flow passing through the radiator impact on the engine and wall which exerts dynamic pressure as drag on the vehicle

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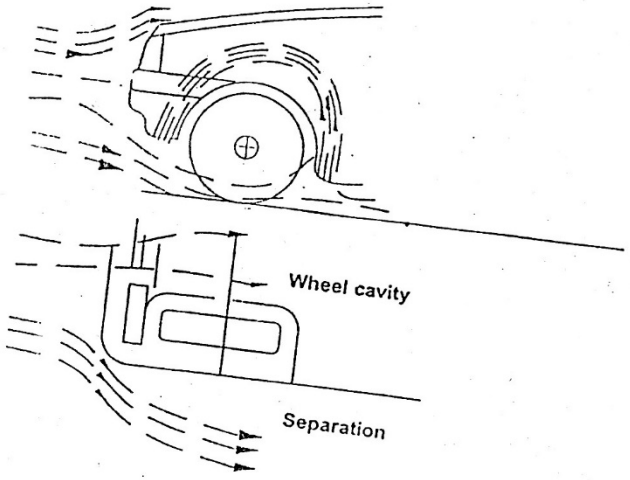
Aerodynamics

Aerodynamic Drag : types & effects

- **Rotating wheels & other**

The wheels and wheel wells are a major contributors at very high speeds (> 150 km / h). The significant drag develops at the wheels because of turbulent, recirculating flow into the cavities. Figure illustrates the complex flow patterns that occur around a wheel



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Aerodynamics

Aerodynamic Drag : types & effects

- **Rotating wheels & other**

  The sharp edges of the wheel cutout provides opportunities to induce flow in horizontal plane, while the rotating wheel tends to induce circulation in vertical plane.

  Other protuberances from the body of the vehicle represent an area contributing to increase in drag and where careful design can improve.

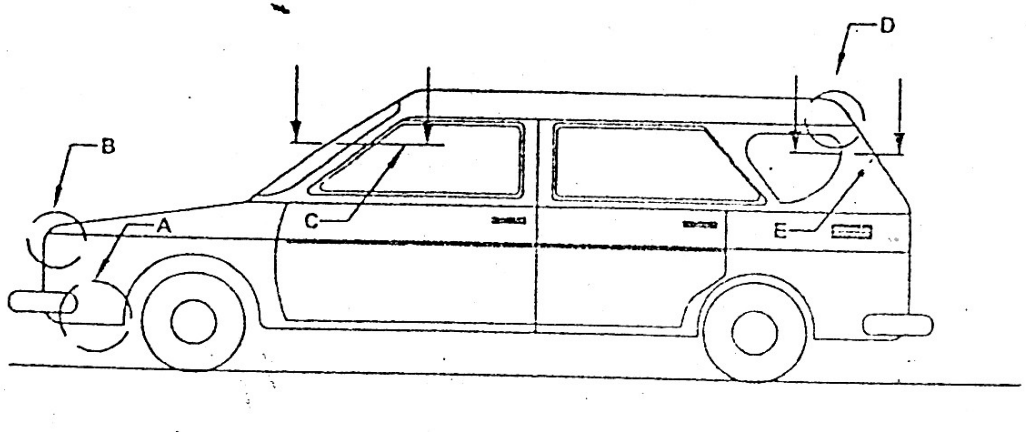
Vehicle Body Engineering

Aerodynamics

Aerodynamic Drag : improvements

Some of the aerodynamic improvements in vehicle body would be highlighted such that the drag could be reduced by minor modifications. As an example, vehicle shows changes that could be considered in ;

A: Air dam, B: hood line, C & D: Pillars, E: Spoilers



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Aerodynamics

A: Air dam

- **The air dam area encircled as 'A' in the figure is the frontal area establishing stream lines, particularly in underbody and wheel areas.**
- **A cleverly designed air dam at the front of the vehicle reduces the requirements of ground clearance and limits the volumes of air passing under the body.**
- **The primary objective of modifications are to reduce pressure of air stream under the vehicle body.**
- **This greatly reduce the vortices and induced drag**

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Aerodynamics

B: Hood line

- It is the leading edge which disturbs the air stream and influence the profile drag. The hood line and the shape of hood should guide the streams without discontinuity over the windscreen.The formation of vortices should also be avoided in this region.

C & D: Pillars

- As shown in the figure the shapes of the two extreme pillars can be effectively applied for optimization of drag. By having a slight convex profile from front to rear pillar the discontinuity can

be eliminated and with it the associated flow separation. The perfectly smooth profile from windscreen to the pillars would be compromised to some extent at the junctions of the glass and the surrounding frames.

E: Spoilers

The spoilers and air foils on the rear check may serve several purposes. The rear spoilers, which is attached either to the rear of the roof or the upper edge of the rear wings, has the effect of increasing the pressure acting on the rear deck area. This

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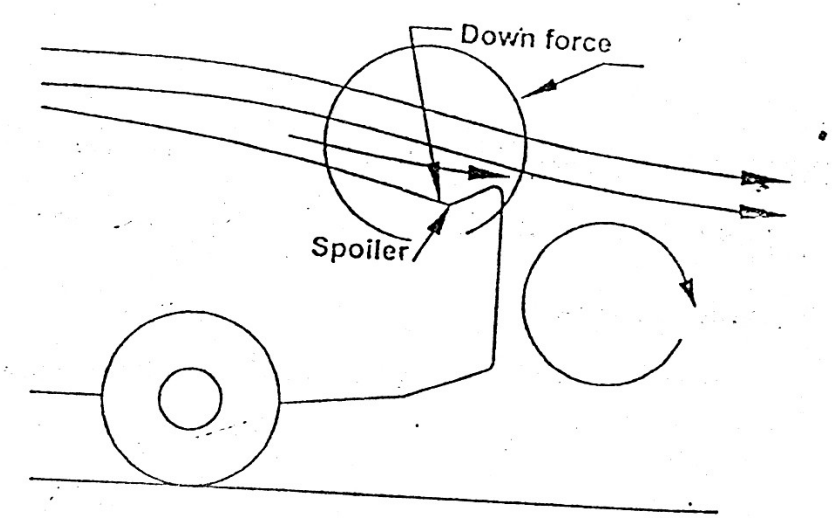
Aerodynamics

increase in pressure acting on the rear deck creates a down force at the most advantageous point as shown in the figure.



- The spoilers may also serve to stabilize the vortices in the separation flow, thus reducing the aerodynamic buffeting.

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Aerodynamics

- **Wind Tunnel Test**

- A wind tunnel tests are used to study the aerodynamic aspects like forces, moments, pressure distribution, drag coefficients, flow patterns, etc.

- There are two basic types of wind tunnels ;

a) Open Circuit tunnels

b) Closed Circuit or Return Flow tunnel

- A wind tunnel is a system or a device wherein provisions are made for air to flow over a scale model of vehicle and the measurements of pressure, forces,

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Aerodynamics

- **Wind Tunnel Test**

and moments etc. can be made.

- **In an open circuit tunnel the air is drawn directly from the atmosphere**
- **In closed circuit or return flow tunnel the air is re-circulated.**
- **The air flow in a wind tunnel is controlled for its velocity and maintained under uniform flow conditions with a low level of turbulence.**
- **The air flows through fan or compressor to cooler to**

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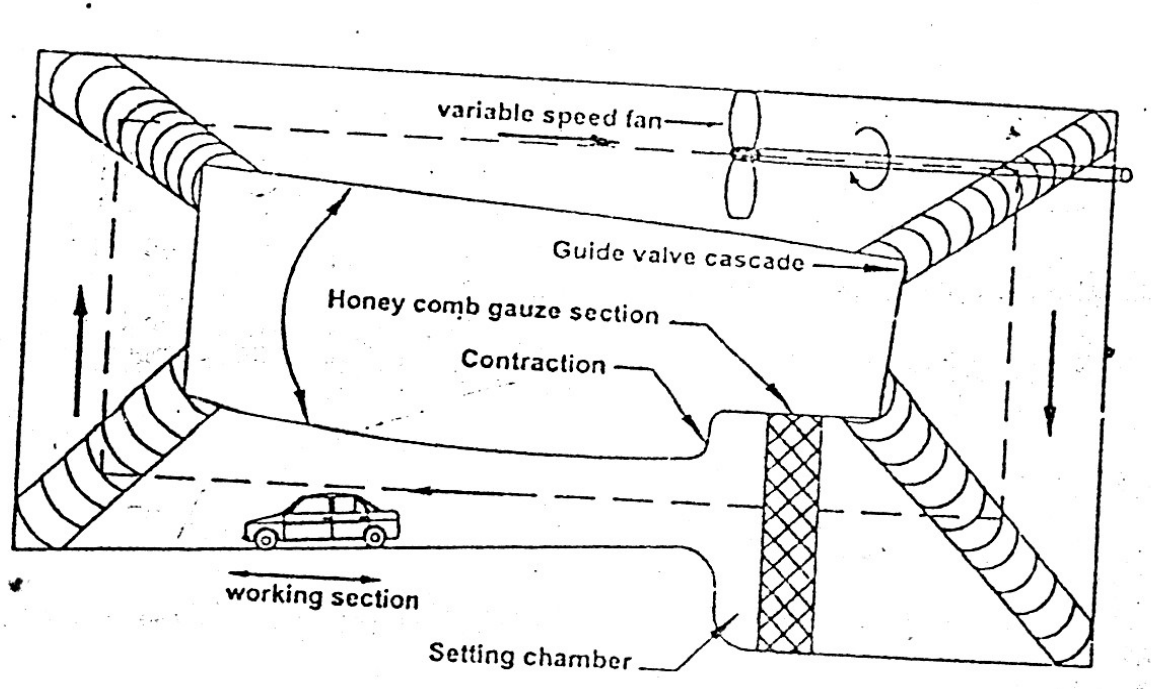
Aerodynamics

- **Wind Tunnel Test**

Test- Section to diffuser and back to compressor or open to atmosphere. Figure shows schematically a wind tunnel



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Aerodynamics

- **Wind Tunnel Test**

- Basically the wind tunnel consists of a set up to produce uniform air flow with variable flow velocities. This is achieved by accelerating and decelerating flow inside the wind tunnel and maintaining uniform flow over the working section.

- The fan is placed in a low speed section providing a flow of air which is accelerated by providing contraction in the down stream as shown. The guide valve cascades, honey comb gauze section, settling

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Aerodynamics

- **Wind Tunnel Test**

chambers are provided for directing and damping the flow. The significance of turbulence is reduced.

- **The model is placed in the working section and is mounted in such a way that permits measurement of forces and moments by the transducers, balance usually mounted out side the tunnel, pittot tubes with manometers, or pressure,velocity,load measurement transducers.**
- **The pressure distribution on the model can be found**

Vehicle Body Engineering

Aerodynamics

- **Wind Tunnel Test**

- from surface pressure tappings. The diameter of these should be small like capillary or hypodermic tubes. The tappings must be flushed with the surface and connected to appropriate manometer or transducer such that readings are obtained and using these values of velocity and pressure the forces, moments, coefficients,etc. can be calculated.

- In a wind tunnel the wind velocity and wind angle can also be measured easily

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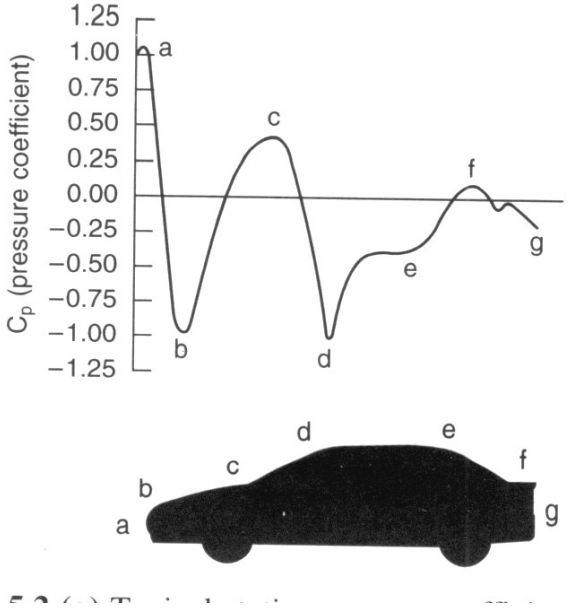
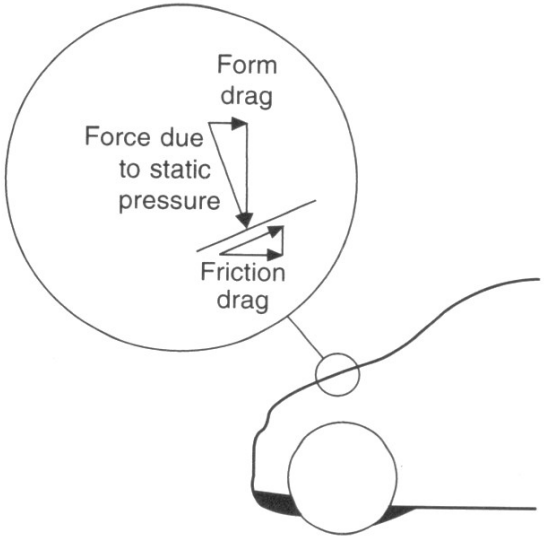
Aerodynamics

- **Typical Static Pressure Coefficient Distribution**

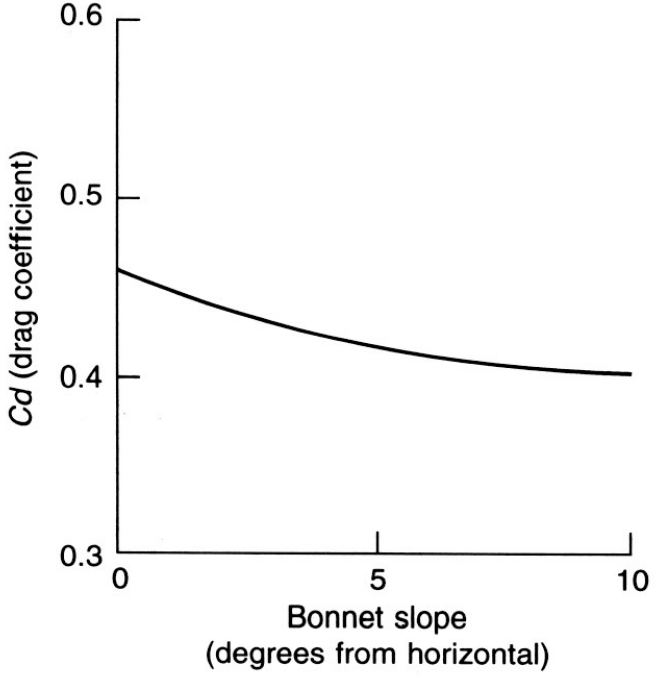


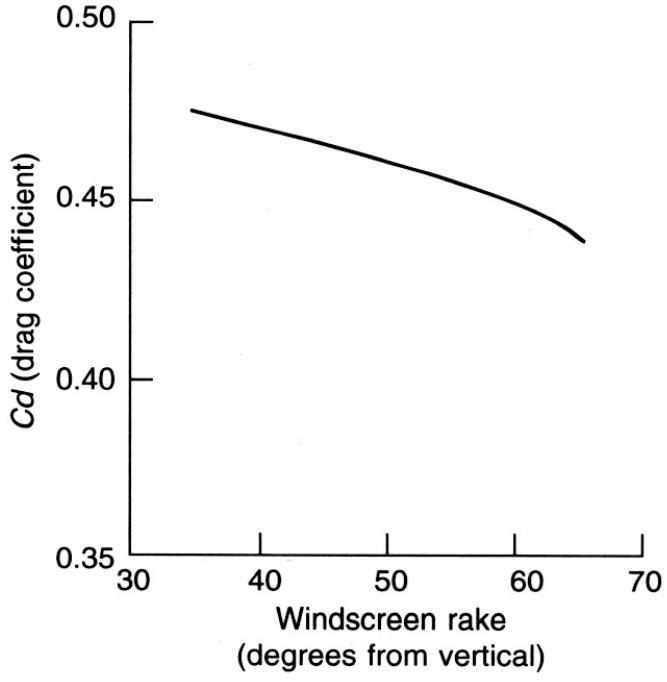


Vehicle Body Engineering

Aerodynamics

- **Drag Reduction by Changes to Front Body Shape**



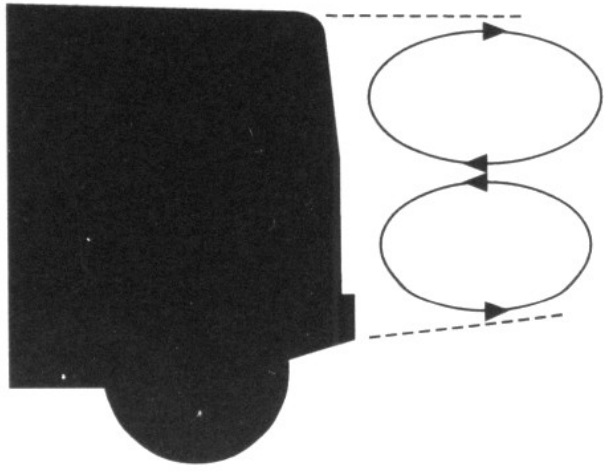


Vehicle Body Engineering

Aerodynamics

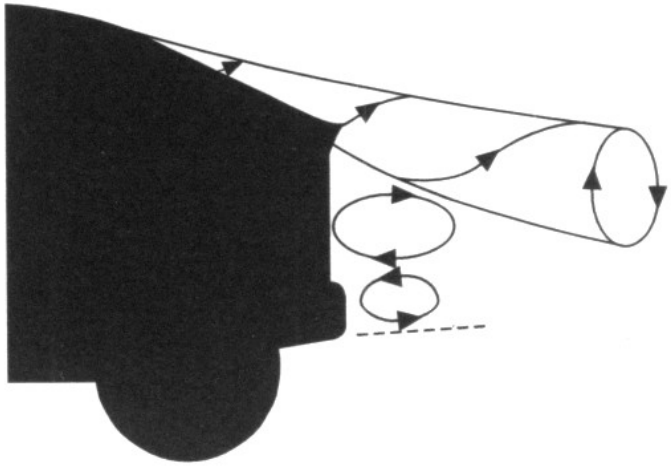
Squareback

large scale flow separation



Hatchback / Fastback

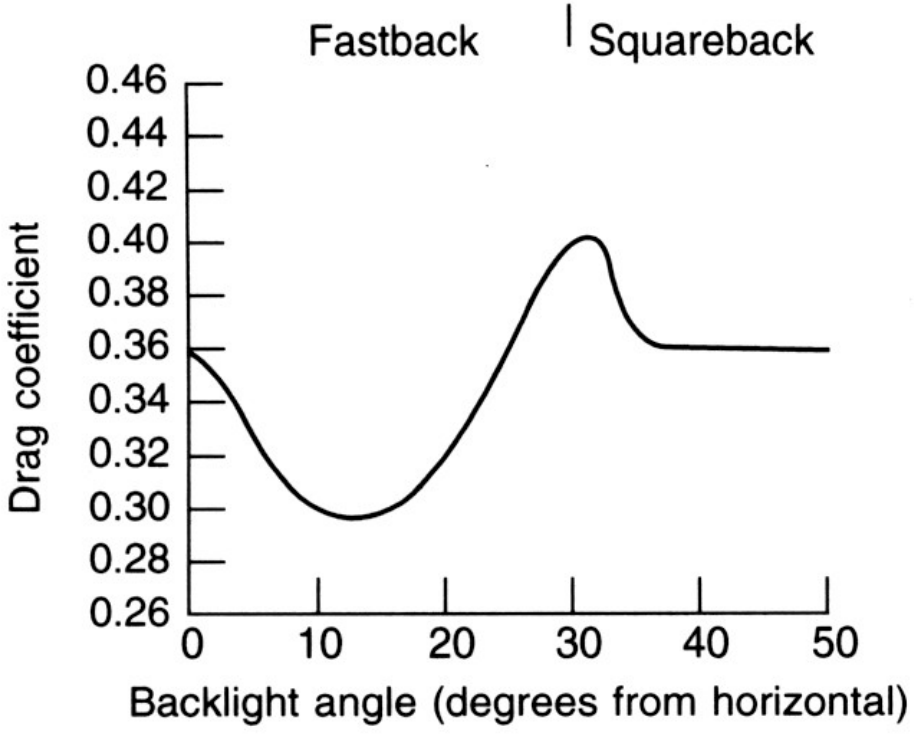
vortex generation



Vehicle Body Engineering

Aerodynamics

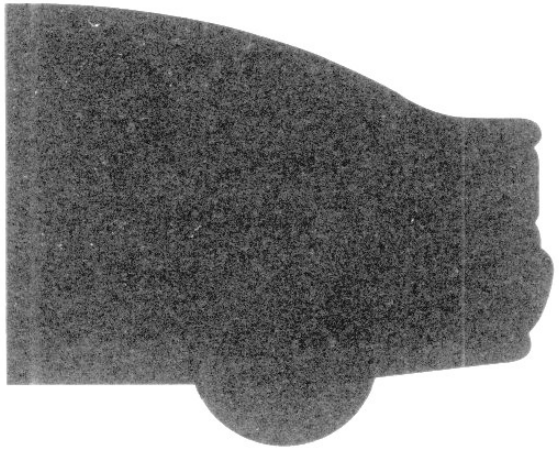
- **Influence of backlight angle on drag coefficient**



Vehicle Body Engineering

Aerodynamics

- **High tail, low drag design**



Vehicle Body Engineering

Aerodynamics

- High tail, low drag design

Vehicle Body Engineering

Aerodynamics

- **High tail, low drag design**

TABLE 3.3 Values of Aerodynamic Resistance Coefficient for Various Types of Vehicle

Vehicle Type	Aerodynamic Resistance Coefficient C_D
Passenger cars	0.3–0.52
Vans	0.4–0.58
Buses	0.5–0.8
Tractor–semitrailers	0.64–1.1
Truck–trailers	0.74–1.0

Source: Reference 3.10.

Vehicle Body Engineering

Aerodynamics

- **Stability and cross- winds**
  - **Aerodynamic stability**
    - **Feel of a car as it travels straight at high speed in calm conditions affected by lane change maneuverability**
    - **Effects of steady cross- winds and transient gusts (atmospheric conditions, embankments, bridges)**

Causes

- **This is largely due to complex interactions between the chassis dynamics and relatively small changes in magnitude of lift forces and center of pressure**
- **Stability degrades with increase in overall lift and differences in lift between the front and rear axles**

Vehicle Body Engineering

Aerodynamics

- **Stability and cross- winds : Comments**
  - **Design vehicles to minimize the side forces, yawing moments and yaw rates that occur as vehicle is progressively and rapidly exposed to cross winds**
  - **The low drag, rounded body shapes are susceptible to cross winds ; increased yaw sensitivity, changes of lift distribution under the influence of cross-winds reduce vehicle stability.**
  - **The aerodynamic influence likely to be further exaggerated by the trends towards weight reduction for improved fuel economy**
  - **Methods of testing models under transient cross-wind conditions are under developments and reliable data at best can be obtained by full scale testing of production and pre-production vehicles.**

Vehicle Body Engineering

Aerodynamics

- **Stability and cross- winds : Comments**

  - **To evaluate the transient behavior of a vehicle at much earlier stage of its design & development require wind tunnel techniques using models and understand the flow mechanisms that give rise to transient aerodynamic forces and moments .**

  - **Studies suggest that forces and yawing moments experienced in true transient case exceed those measured under steady state conditions.**

Vehicle Body Engineering
Aerodynamics

- **Aerodynamic Noise**

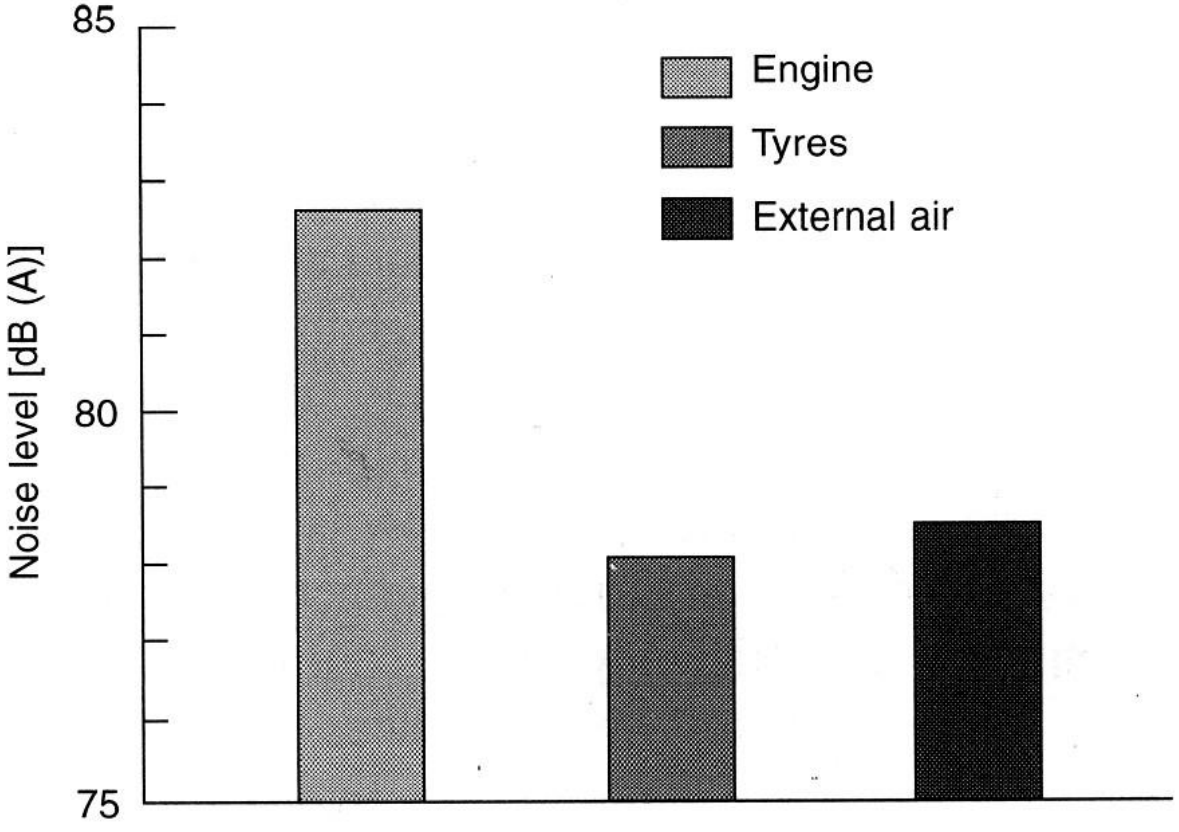
  - **Some aerodynamic noise is created by ventilation flows through the cabins**

  - **Major obtrusive noise is generally created by the external flow around the vehicle body**

Vehicle Body Engineering
Aerodynamics

- **Aerodynamic Noise**

- **Comparison of different noise sources in a car moving at 150 km/h**



Vehicle Body Engineering

Aerodynamics

- **Creation Aerodynamic Noise**
  - **Mostly associated with turbulence at or near the body surface**
  - **Essentially associated with the random turbulence that occurs within a turbulent boundary layer**
  - **It is the sound associated with eddy (vortex) creation at surface discontinuities that has both the greatest magnitude and also the clearly defined annoying frequencies (entire audible range).**
  - **One of the largest single noise generator is the sun roof. Its large size results in low frequencies & large magnitude. Poorly designed units may even lead to discernible low frequency pressure pulsing in the cabin.**

Vehicle Body Engineering

Aerodynamics

- **Reduction in Aerodynamic Noise**
  - **Reduction in noise can partly be through – improved air flows with reduced noise creation and by improved sealing reducing both its creation & insulation of occupants from the source.**
  - **Considerations to reduce drag inevitably provide benefits of noise reduction**
  - **Improvements in ;**
    - **rain gutter designs,**
    - **positioning of windscreen wipers,**
    - **manufacturing techniques & quality control of improved panel fit,**
    - **protrusions such as wing mirrors, small surface radii such as at 'A' pillar**

Vehicle Body Engineering
Aerodynamics

- **Underhood Ventilation**

  - **Underhood flow restrictions arising from engine cooling system and ever-increasing volume of ancillary equipments under the bonnet has focused attention on cooling air flows.**

  - **Evidence from numerous researchers suggests that the engine cooling system is responsible for 10 to 15% of overall vehicle drag.**

  - **Considerable effort are being focused on optimisation of these flows including development of computational flow simulation codes.**

Vehicle Body Engineering
Aerodynamics

- **Underhood Ventilation**

  - **Many of the source of cooling drag are; resistance created by the dense radiator matrix and the drag associated with the tortuous flow through the engine bay.**

  - **Less obvious but significant is the interaction between the undercar flows and the cooling flows at the exit where high turbulence levels and flow separations may occur**

  - **Careful design to control the cooling exit flow in terms of its speed and direction can reduce the drag associated with the merging flows**

Vehicle Body Engineering

Aerodynamics

- **Potential for Underhood drag reduction**

  - **Greatest reduction possible if air flow can be controlled by use of ducting to guide the air into and out from the radiator core.**

  - **The high blockage caused by the radiator core has the effect of dramatically reducing the air velocity through the radiator and much of the air spills around it.**

  - **The slow- flow ducted in a controlled and efficient manner by careful design, enhancing the degree of diffusion, reduces both the drag force and the heat transfer. This require larger radiator core surface area. A careful compromises are necessary.**

Vehicle Body Engineering
Aerodynamics

- **Cabin Ventilation**
  - **Sealing between the body panels and around doors benefits in reduction of noise and aerodynamic drag. But almost complete elimination of leakage require passenger compartment ventilation.**
  - **Cabin ventilation flow require attention to intake and exit locations as well as the velocity and path of fresh air through the passenger compartment.**
  - **The intake should be located in a zone of relatively high pressure not too close to the road to avoid particulates and pollutants. The region ahead of windscreen adequately meets such requirements and conveniently located for air entry for ventilation and air conditioning.**

Vehicle Body Engineering
Aerodynamics

- **Cabin Ventilation**

  - **For effective extraction of ventilation air, a zone of lower pressure should be sought. A location at the rear of the vehicle is usually selected. Air is directed through the parcel shelf and boot to exit through a bleed in the boot seal.**

  - **Increasing the pressure difference between the intake and exit provides the potential for high ventilation air flow. This can be noticed in heated-air conditions inside the cabin.**

  - **Recent trends has been to use low pressure difference coupled with fan/ blower assistance for simple ventilation or air conditioning systems.**

Bus & Truck Aerodynamics

Dr. Mukesh Saxena

University of Petroleum & Energy Studies

Dehradun

Bus & Truck Aerodynamics

Background

- Commercial Vehicles are less streamlined
- In general aerodynamic drag is less significant due to lower speeds
- Rolling resistance is high due to vehicle weight and payload
- Drag Coefficient of a truck or a bus may be twice that of a car due to frontal area (2-3 times higher)

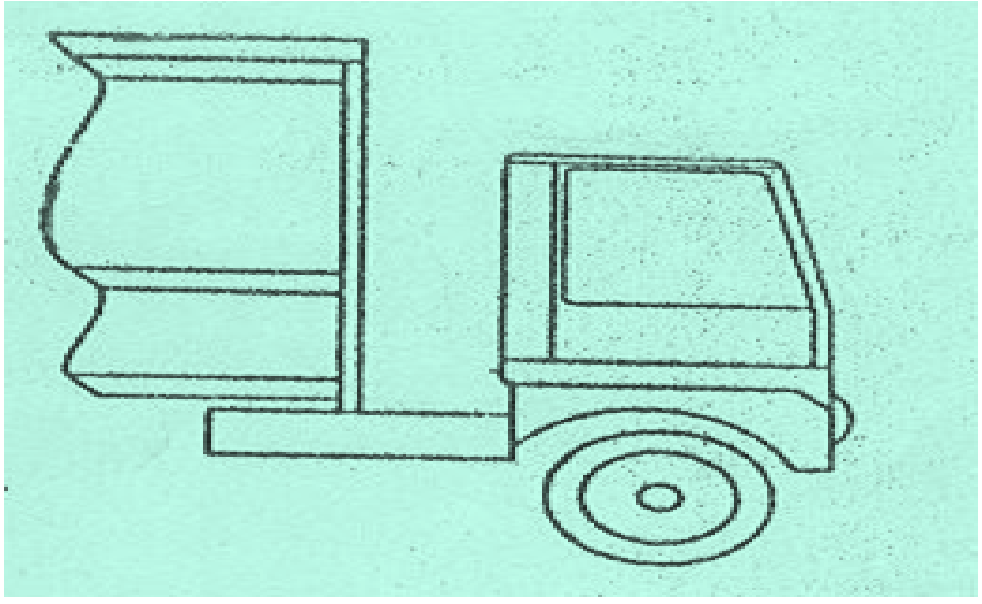
Bus & Truck Aerodynamics

- Total resistance (rolling+aerodynamic) can be of considerable magnitude at high speeds

- Aerodynamic improvements desirable for
  - saving engine power,
  - reduction in fuel consumption & emissions

Bus & Truck Aerodynamics

- **Methods of Reducing Aerodynamic Drag in Trucks**
  - **Aerodynamic behavior is additionally more complex because of tractor trailer combination**
  - **Tractor trailer combination has air gap between the units**



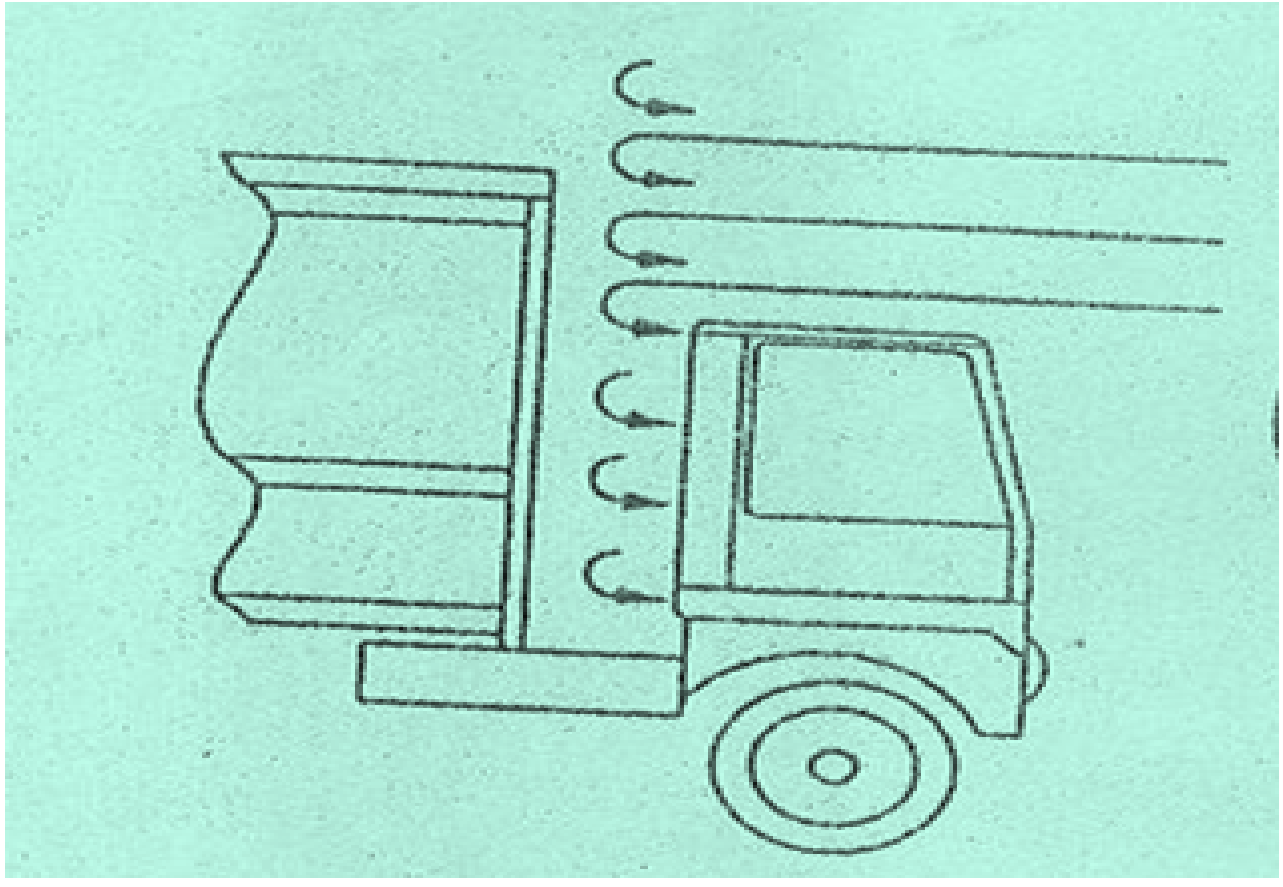
Air Gap Between Tractor & Trailer

Bus & Truck Aerodynamics

- As air gap exists the flow above tractor roof divides with some downward flow associated with turbulence between the tractor trailer
- Drag reduction can be caused by tractor smoothing the air flow on to the trailer
- Drag increases as separation increases due to down flow

Bus & Truck Aerodynamics

- **Methods of Reducing Aerodynamic Drag in Trucks**

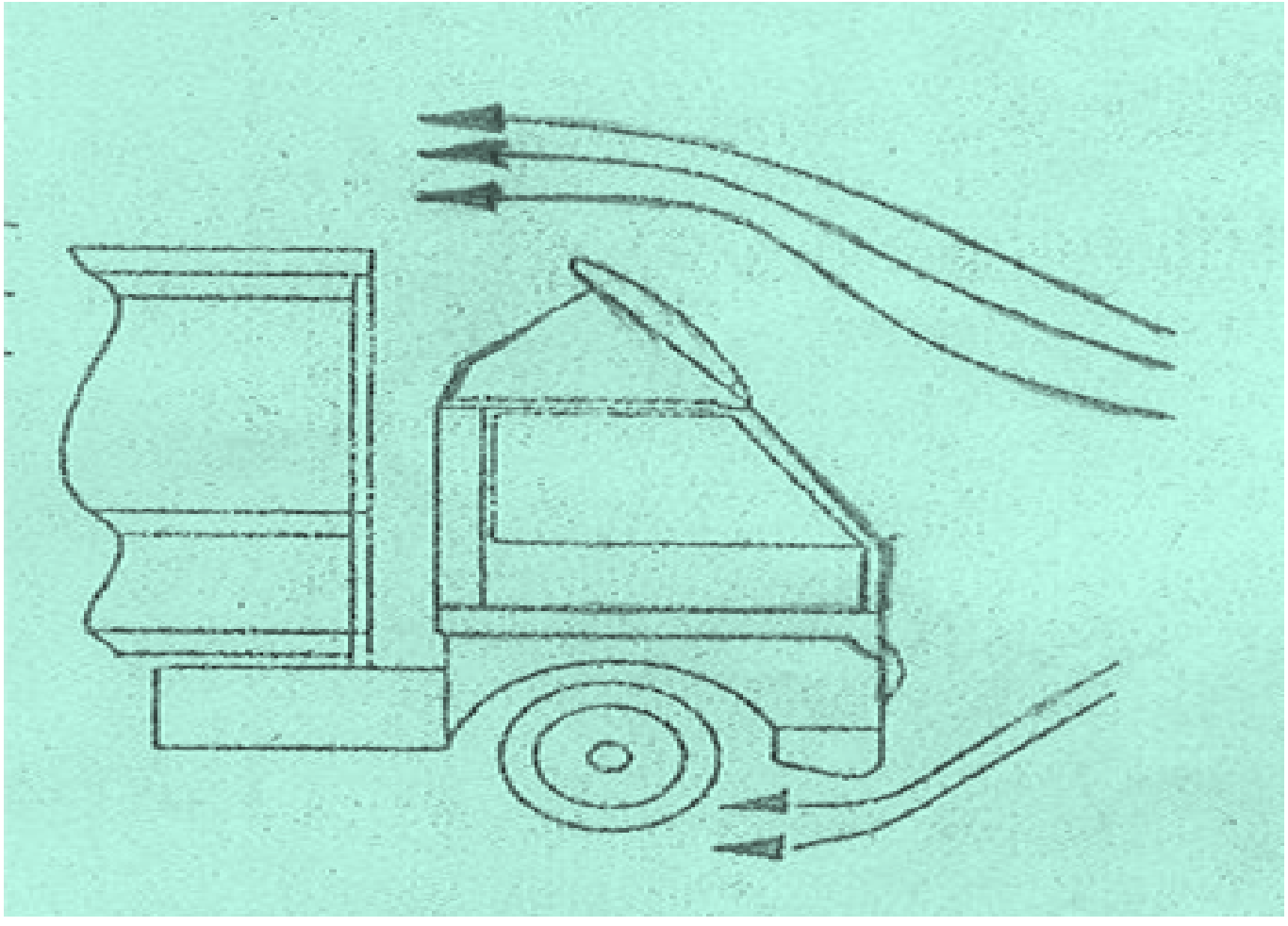


Air Flow without Deflector

Bus & Truck Aerodynamics

- This increase in drag can be virtually eliminated using horizontal plate to inhibit the down flow
- By fitting deflectors, foils or fins to the Cab top streamlining of the air flow as it passes over and around the cab/ tractor, deflectors/ foils or fins, the drag on the vehicle reduces
- Some further streamlining can be achieved by fitting air dams to the lower parts of the cab front and nose panels to the front of the trailer box

Bus & Truck Aerodynamics



Air Flow with Deflector

Bus & Truck Aerodynamics

- Deflectors are usually made from glass-reinforced plastics and can be easily fitted / removed from vehicle

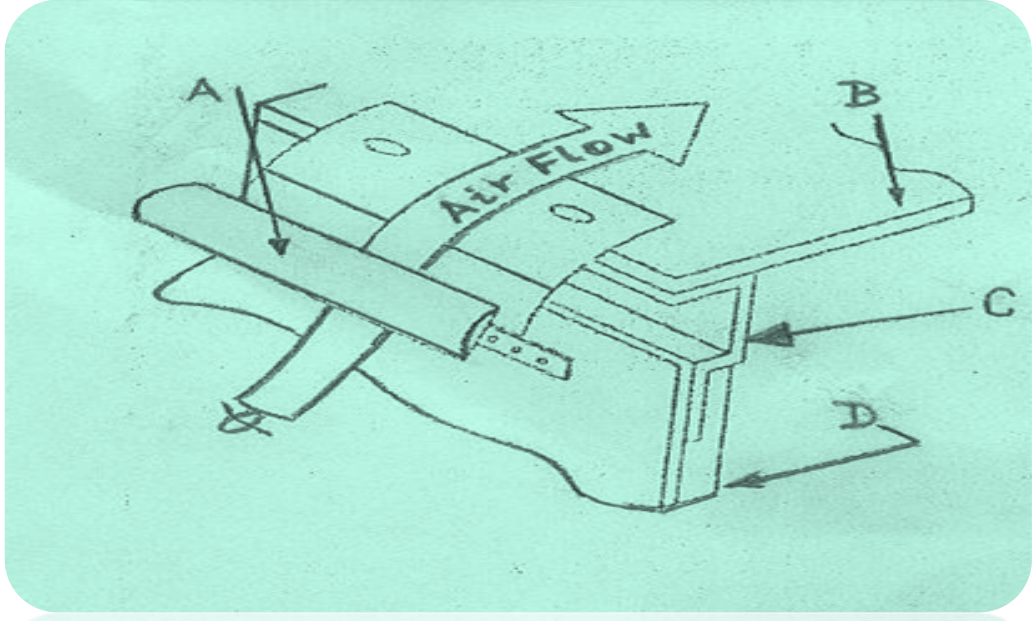
- It is important that roof deflection should be at correct angle and height to obtain maximum advantage from the Deflectors

Bus & Truck Aerodynamics

- **Air Vane – air flow guide**
  - **Air vane devices as the air flow guide are designed and perfected by extensive wind tunnel testing**
  - **It helps to sooth out the air flow over a vehicle**
  - **It is a light weight aerodynamic device that can be installed easily on the front of any vehicle body.**

Bus & Truck Aerodynamics

- **Air Vane – air flow guide**
  - **A reduction in air drag can lead to significant fuel savings – as much as 14.5% at 88 km/hr.**



A : Air Vane Device

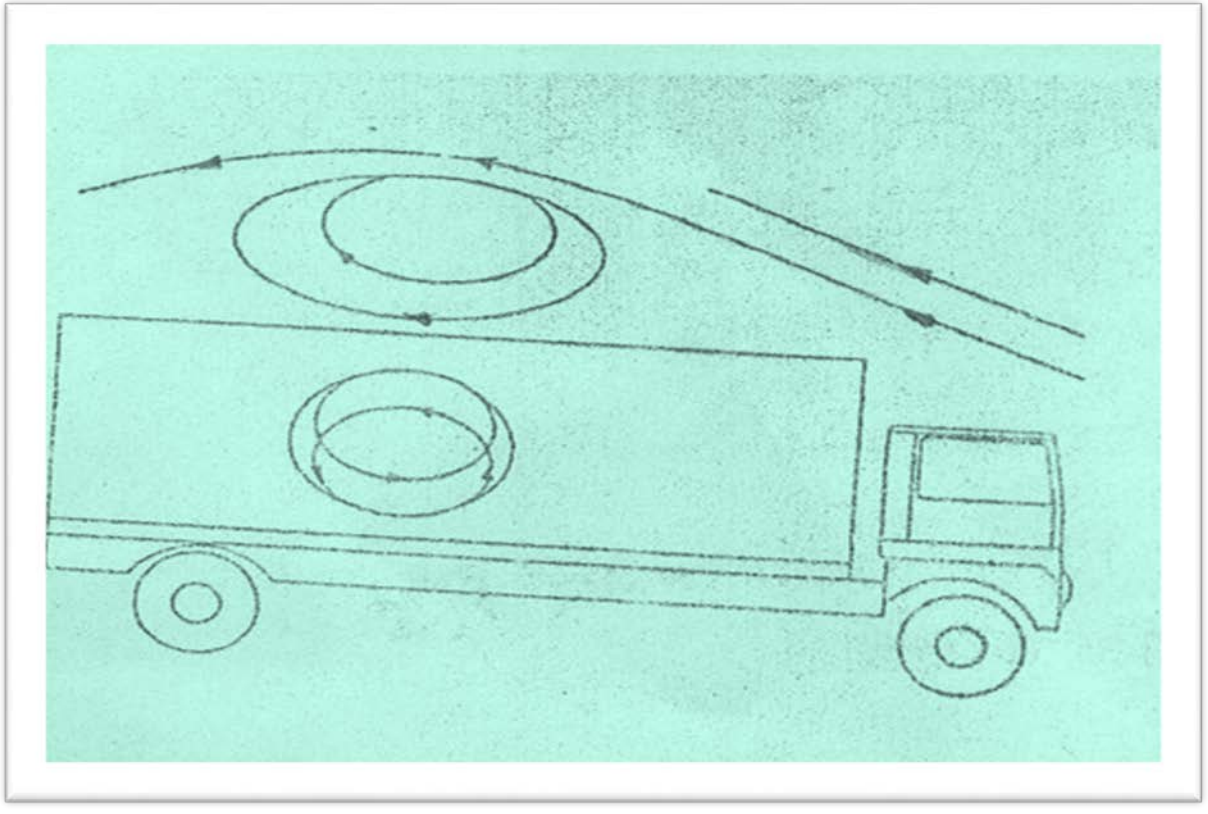
B : Roof Panel

C : Roof Rail

D : Bulkhead Pillar

Bus & Truck Aerodynamics

- A typical truck or trailer creates the kind of air turbulence as shown at highway speeds



Truck without Air Vane Airflow Guide

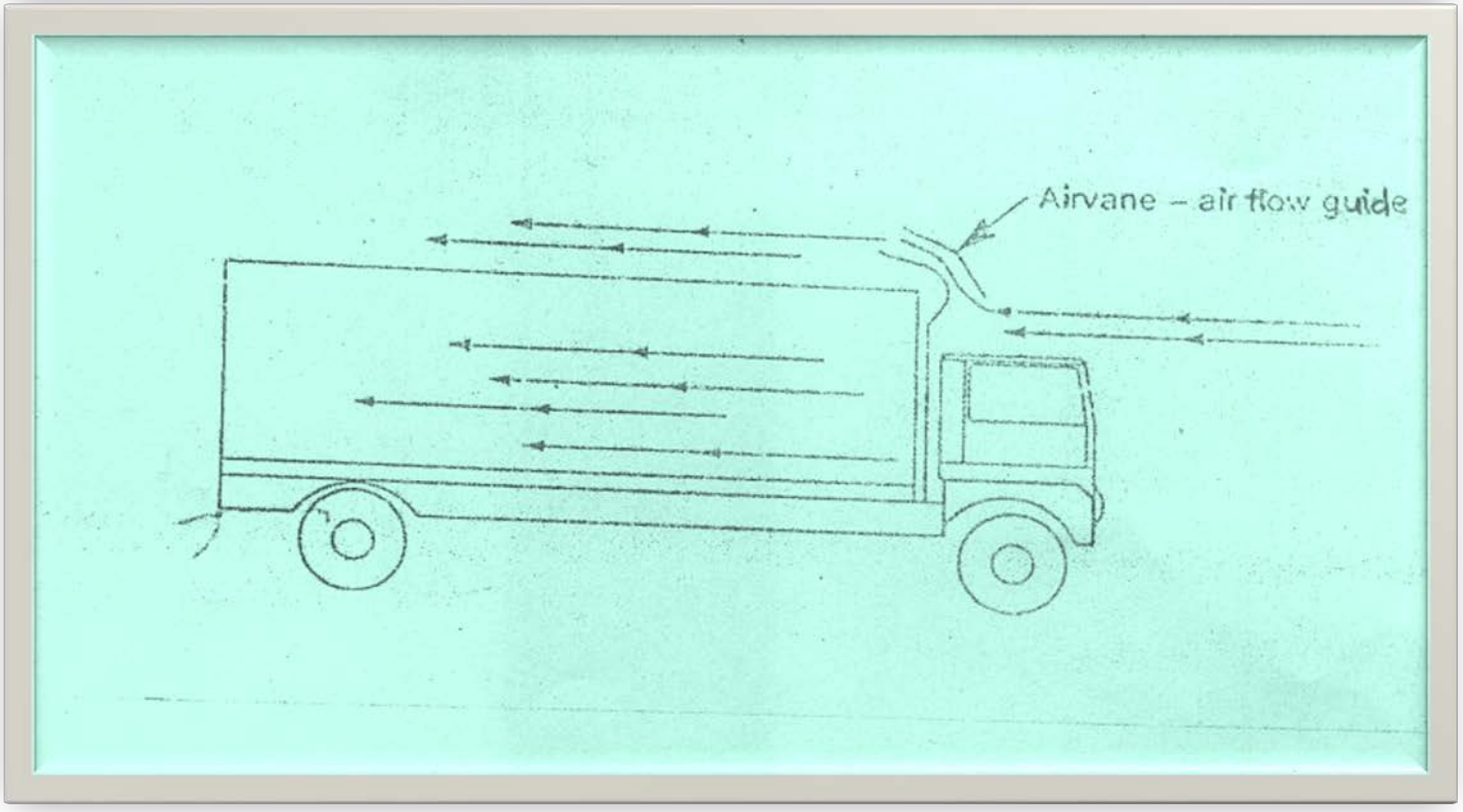
Bus & Truck Aerodynamics

- Increased air drag actually increases the effective frontal area leading to excessive power & fuel consumption

- With complete air vane installed the air flow on the top and the sides of a vehicle is smoothened greatly to reduce turbulence and air drag as shown.

Bus & Truck Aerodynamics

Methods of Reducing Aerodynamic Drag in Trucks



Truck with Air Vane Airflow Guide

Bus & Truck Aerodynamics

- **Low drag affects;**
  - **Reduce fuel consumption**
  - **Reach to higher speed with a given power out put**
  - **Reduction in power at any lower speed the available greater power surplus gives better acceleration**
  - **Under braking, low drag impair performance offering less resistance of continued motion**

Vehicle Body Engineering

Bus Body Details

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Vehicle Body Engineering

Bus Body Details

Introduction

- Buses are used for transportation of people and these are generally classified according to:
  - A. Size and passenger carrying capacity
  - B. Body shape

- According to size and capacity these buses are commonly identified as ;
  - a) Mini bus
  - b) Town bus
  - c) Suburban bus
  - C) Luxury coach

Vehicle Body Engineering

Bus Body Details

Introduction

Table below gives the types of buses and their approximate range of passenger capacity

S.No.	Type of Bus	Passeger Capacity
1	Mini bus	15 – 26
2	Small coaches for long distance	16 – 30
3	Small buses for towns	upto 40
4	Medium coaches for long distance	31 - 45
5	Medium buses for towns	41 - 60
6	Large coaches for long distance	46 – 60
7	Large buses for towns	61 – 80
8	Large articulated bus	> 80

Vehicle Body Engineering

Bus Body Details

- **Brief features of different types of buses**

➢ **Mini bus**

- should have seating capacity up to 26

- normally built on light duty chassis

- front mounted engines, rear axle derive, soft & comfortable suspension, reasonably comfortable seating and fairly small entry platform

➢ **Town Bus or City Bus**

- Such buses are used for short distance journeys of up to 30 km.

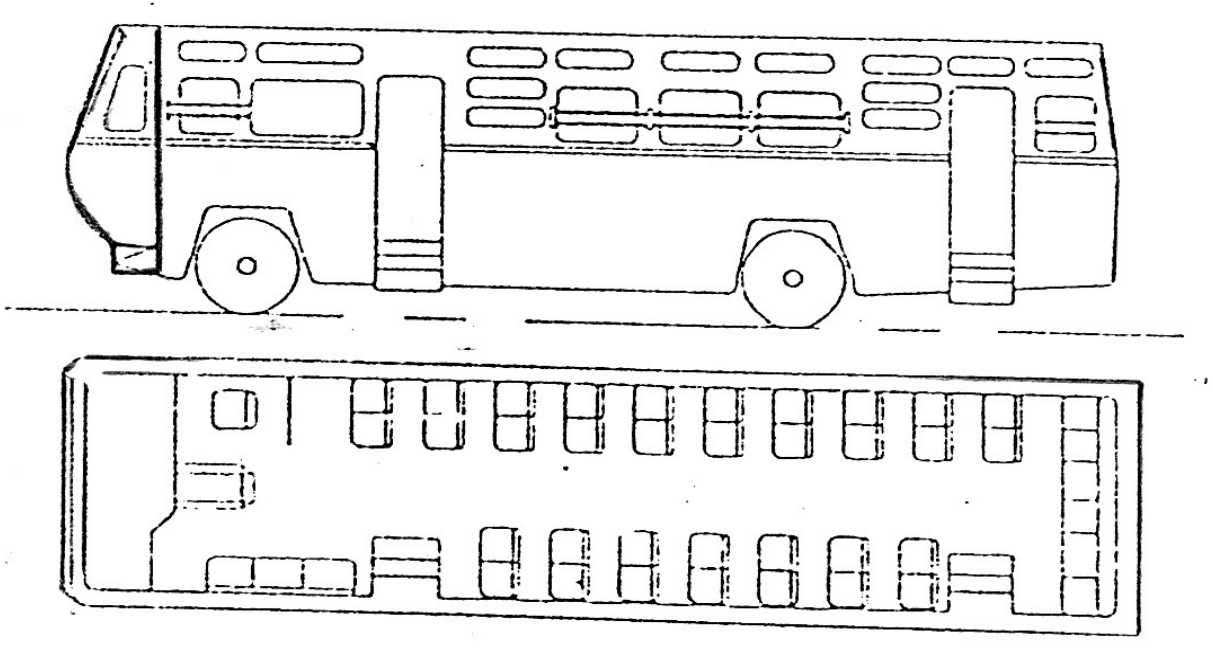
- a large standing space and relatively hard seating

Vehicle Body Engineering

Bus Body Details

usually covered with durable trim materials such as PVC, etc.

- due to short intervals between stops in local traffic, such buses are provided with wide entrance & exit doors with low steps entry & exit platforms.



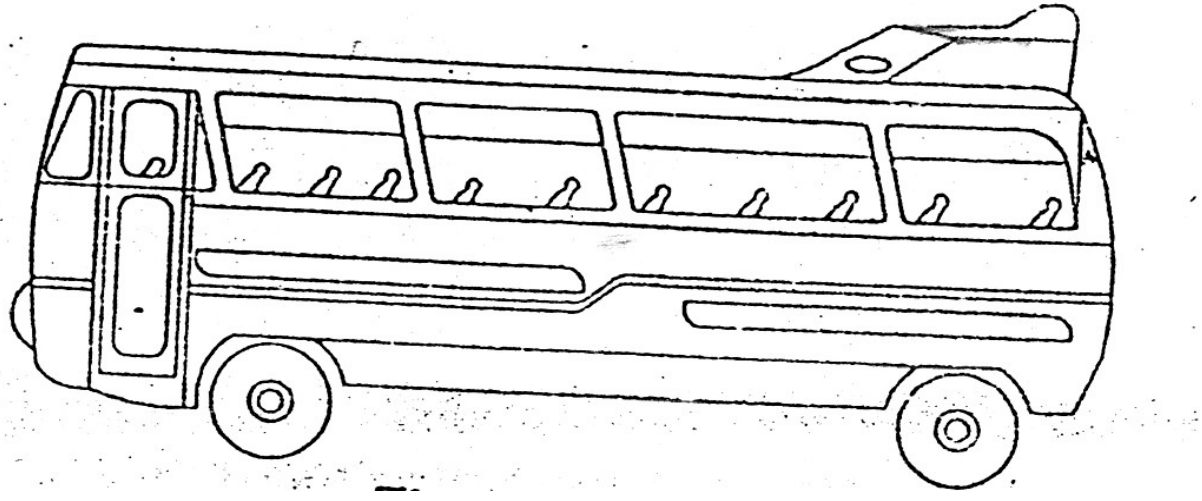
Vehicle Body Engineering

Bus Body Details

- **Brief features of different types of buses**

➢ **Suburban Bus**

- **These buses are used for a distance of about 40 kms.**
- **should have reasonably comfortable seating for about 38 persons with roof rack for hand luggage.**
- **generally small entry platforms with single door.**



Vehicle Body Engineering

Bus Body Details

- **Brief features of different types of buses**

➢ **Luxury coach**

- The luxury buses have a very comfortable seats with under floor luggage space and roof rack for hand luggage.

- Air conditioning, TV, VCR, music system, etc. are provided in the coach body.

- wide windows or additional windows upto the roof are used to improve visibility for the passengers

Vehicle Body Engineering

Bus Body Details

- **Classification of buses based on body shapes**

➢ **Classic type**

➢ **Single deck**

➢ **Double deck**

➢ **Two level single decker**

➢ **Articulated**

➢ **Classic type**

- Engine is mounted in front of the passenger compartment

- Disadvantage include low ratio of useful length to over all length.

- Poor aerodynamic shape

- Presently not in much use except partially as school bus

Vehicle Body Engineering

Bus Body Details

- **Classification of buses based on body shapes**

➢ **Single deck**

- In this type of buses engine is mounted either inside or below the driver's cab enabling additional length available for more seats and a better angle of vision.

- Such buses may have one or two doors.

- Many single deck models have seating capacity of fifty two which in city buses is reduced to have more space for standing. This enable transportation of more passengers for short duration.

Vehicle Body Engineering

Bus Body Details

- **Classification of buses based on body shapes**

➢ **Double deck**

- **These buses have rear mounted engine which affords a front entry or good forward visibility for passengers**
- **Such buses have passenger capacity of approximately sixty five to seventy five. It may have upper deck open for tourists.**
- **Double decker buses have poor stability than single decker buses**

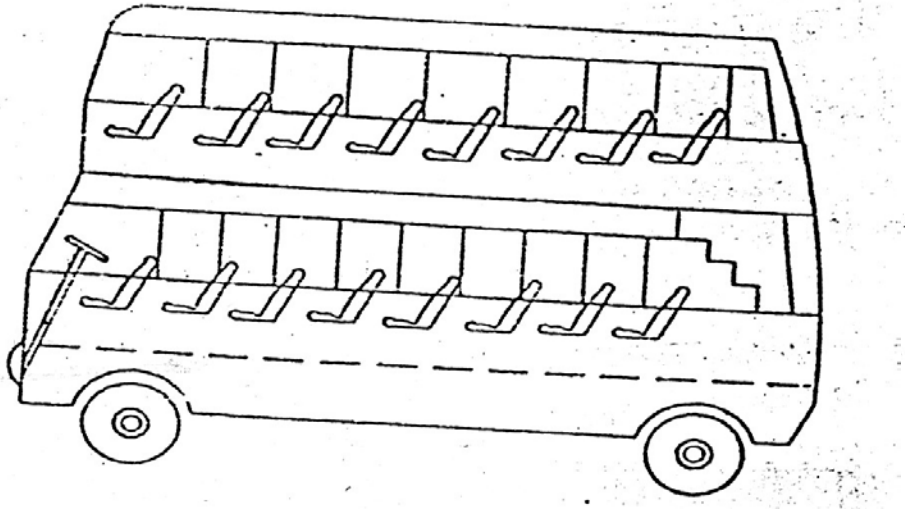
Vehicle Body Engineering

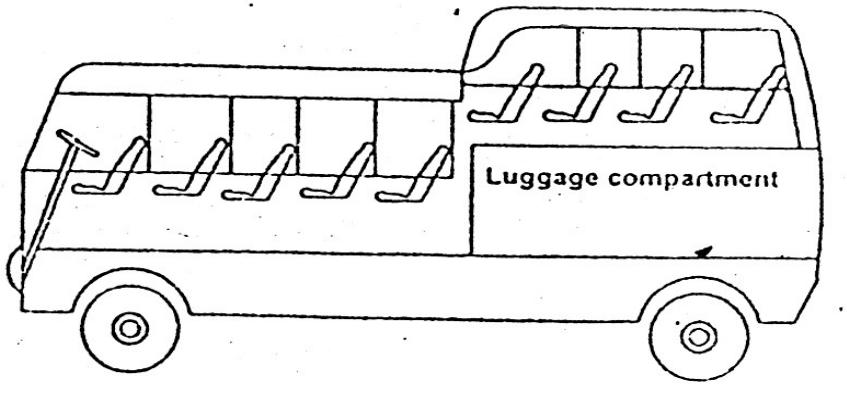
Bus Body Details

- **Two level single decker**

- This type of buses are used as luxury coaches.

- The layout provides good forward visibility for all passengers and good separate luggage space under floor





Vehicle Body Engineering

Bus Body Details

- **Classification of buses based on body shapes**

➢ **Articulated Buses**

- These are very large coaches for in-city operation. These are made of two parts because of axle load limitations. The rear is articulated to the main vehicle