Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.

2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given more importance. (Not applicable for subject English and Communication Skills).

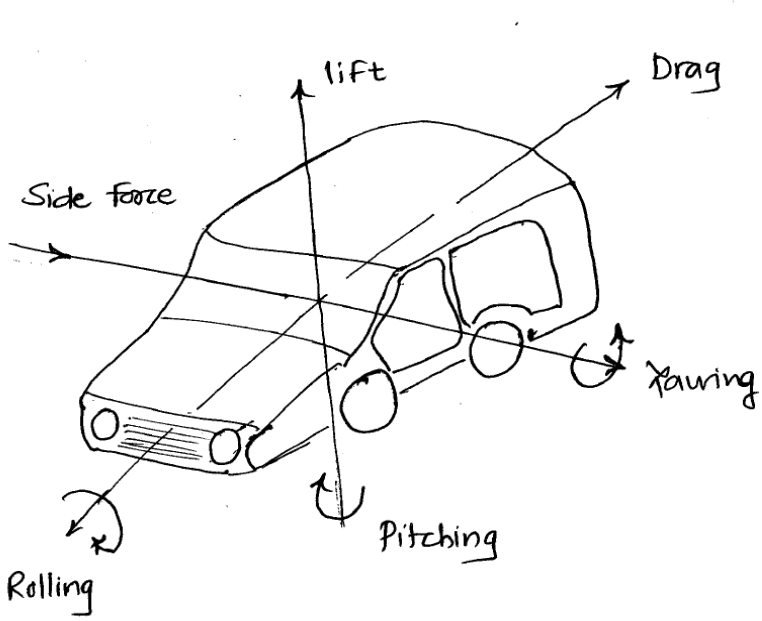
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.

5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.

6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.

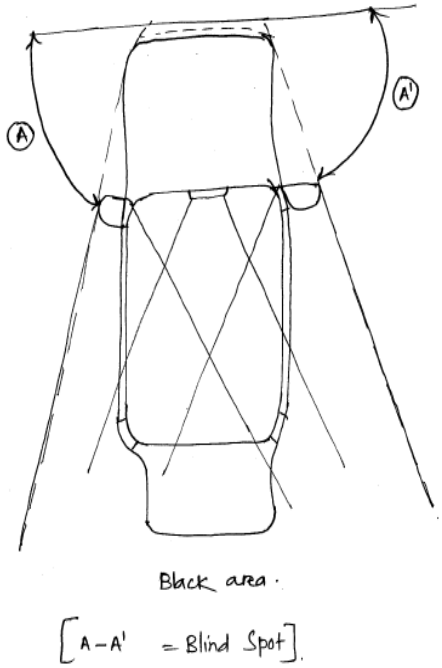
7) For programming language papers, credit may be given to any other program based on equivalent concept.

1. Attempt **any five** of the following	**20**
a) State four practical objectives of aerodynamics.	04
Answer: Practical objectives of aerodynamics: Following are the practical objective of aerodynamics: 1. The prediction of forces and momentum and heat transfer of moving body through a fluid usually air. e.g. the generation of lift, drag, moment on the aerofoil structure , to measure the wind forces on building, ships and other surface of vehicle, to calculate the aerodynamic heating of flight vehicle ranging from supersonic transport to planetary probe. 2. Determination of flow moving internally through the ducts or pipe. e.g. we can calculate and measure the flow properties inside rocket and jet engine 3. Design of choosing the shape of body e.g. by considering various factors such as lift, drag, appearance of the vehicle, cost for manufacturing, customer's requirement, the science of aerodynamic is useful for selection of proper shape of the vehicle body. 4. It is useful to maximize the fuel efficiency and engine performance by studying the various factors like lift, drag, pressure, flow velocity, temperature.	04
b) Describe with example future trends of aerodynamics	04
The term future trends are a state of art, it refers through the current level of technical development to reduce aerodynamic forces and increase the vehicle efficiency. The emerging regulations and the growing public perception about fuel consumption, CO_2 emissions, safety and comfort are driving manufactures towards an unprecedented level of energy efficiency of vehicles. Novel challenges are then facing aerodynamicists, in order to meet tighter and tighter targets about drag reduction and, at the same time, design vehicles that are quieter, safer, more comfortable and pleasant. By minimizing the drag we can improve the fuel efficiency. There are two different methods to reduce the aerodynamic drag is to reduce the frontal area and improving the shape of body. The easiest way to improve the fuel economy to make it smaller and lighter and give a small engine. But to reduce the size and weight of engine is not easy to do because of comfort and safety also. If the mass of car is not reduce properly. It losses the engine performance due to small engine size. The three box version is still most popular and the two box version come to second and more recently trends has been evaluated in single box car with low drags stream line shape. Example: Design and development of small car carried out by considering all the factors discussed above.	04

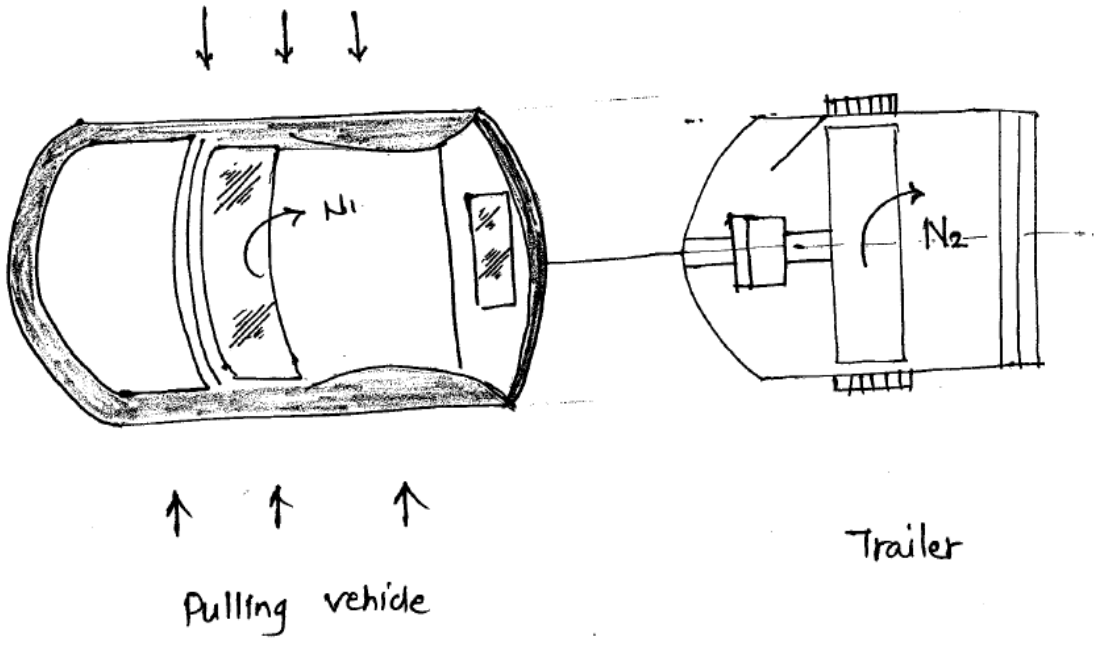
c) Draw a schematic diagram of a car showing aerodynamic forces and moments acting on it.	04
 Fig :schematic diagram of a car showing aerodynamic forces and moments	04
d) What are the requirements of child seat design with respect to ergonomic consideration?	04
Answer: Requirements of child seat design (Any four) 1. The child seat has to withstand flammability test so that it can't catch fire in any circumstances. 2. It should be washable. 3. The child seat is must be with seat belt or harshening safety to protect the child to the collision occurs. 4. The child seat should be manufactured under government regulation which establishes the seat back height, buckle release pressure. 5. The child seat should be made of polypropylene which is tough plastic and very hard to crack. 6. It should be low in cost. 7. It should be comfortable for child. 8. It should be fashionable, colorful and durable.	1 Mark for each

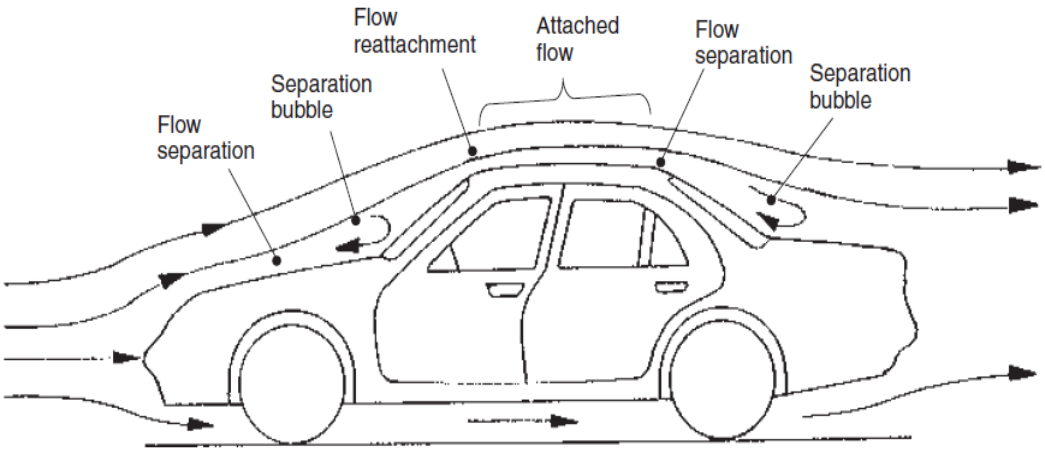
e) What are the different types of car bodies?	04
Answer: Different types of car bodies (02 Marks for main types & 02 Marks for sub types) Types of car bodies: 1. Closed car a. Sedan or saloon b. Hatch back or lift back c. Coupe d. Limousine 2. Open car a. Convertible b. Sports 3. Special types a. Vans b. Station wagon c. Pick ups d. Sport utility vehicle or multipurpose vehicle.	04
f) Define the terms i) Lift ii) Pitching iii) Rolling iv) Yaw	04
Answer: Definitions: 1. **Lift:** it is an aerodynamic force which acts right angle to the direction of motion is known as lift. or lift is a component of force which is perpendicular to the air flow. 2. **Pitching:** The rotating action produced in the vehicle about a transverse axis which is parallel to ground is known a pitching moment. 3. **Rolling:** while corning the centrifugal force produce a movement of the vehicle about longitudinal axis is known as rolling. 4. **Yaw:** it is lateral force acts on the side of the vehicle is nor-mid of the wheel base is known as Yaw.	01 01 01 01
g) Describe the terms – tractive efforts and traction.	04
Answer: **Tractive efforts:** it is force available at the point of contact between the rear wheel tyre and the road. The driving force is always parallel to road surface of the wheel.	

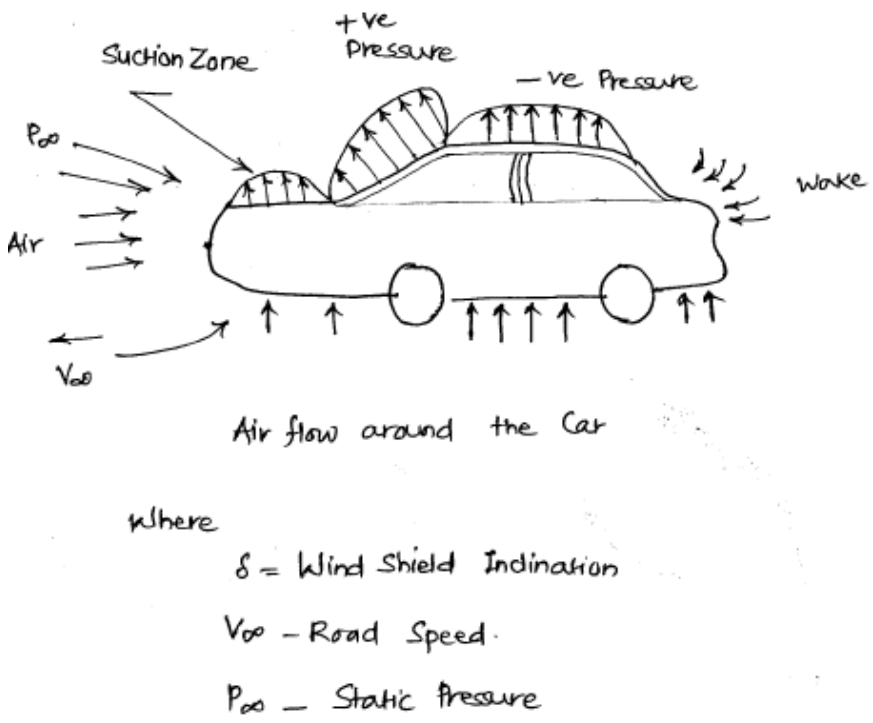
Tractive efforts = $\frac{\text{Torque at rear wheel}}{\text{Radius of wheel}}$ Engine torque, Te = $\frac{60000\,P_e}{2\pi N}$ N-m Torque at rear wheels, $T_w = (g.r. \times a.r.)\eta_t T_e = G\eta_t T_e$ Tractive effort, F = $\frac{T_w}{r} = \frac{T_e\,G\eta_t}{r}$ N Where P_e = engine b.p.kW T_e = mean engine torque in N-m η_t = overall transmission efficiency g.r= gearbox gear ratio a.r = back axle ratio G= overall gear ratio r = radius of tyre in meter and N= r.p.m. of crank shaft. **Traction:** it is the ability of rear wheel to transmit the tractive effort without slipping is called traction. Unusual tractive effort will never exceed traction.	04
2. Attempt **any four** of the following :	16
a) What is Blind spot? Give the two examples.	04
Answer: Blind Spot: Area of the road and around the vehicle which don't see the driver while looking forward either rear view or side view mirror. The areas most commonly refer to the blind spot are the rear quarter. Blind spot is also generated due to frontal area of the vehicle, mirrors and pillars. The blind spot can be reduced by adding side and rear view mirror, by using rear video cameras, distance sensors etc. There is also various advance equipments like fish eye mirror or spot mirror. Recently development in technology using the aspheric mirror which allows the blind spot to be eliminated while looking minimum view is seeing in large size.	02

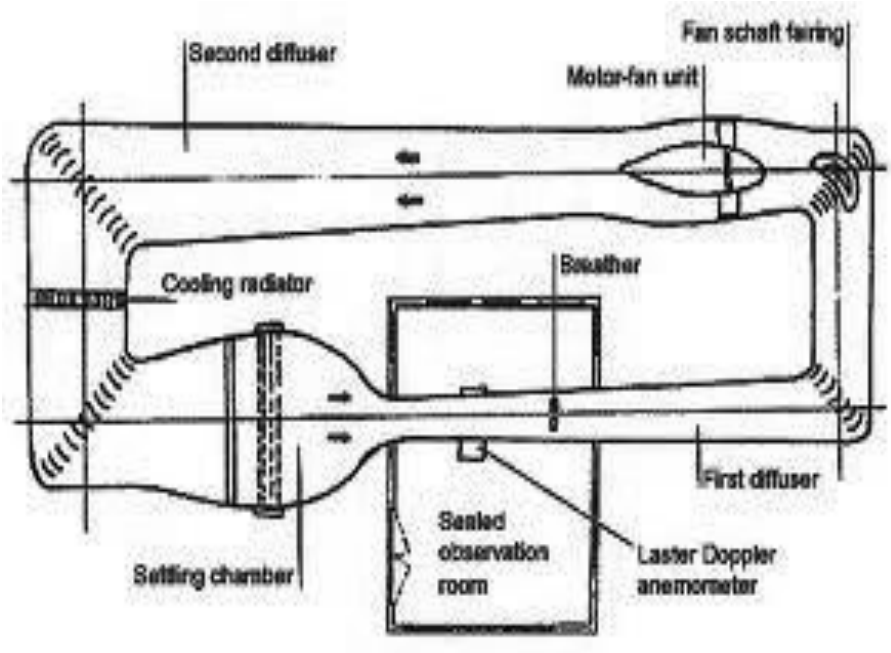
 Fig: Blind spots	01
Examples: 1. The longer vehicle such as commercial vehicle has longer rear blind spot as well as longer front and rear blind spot. 2. The area exactly opposite to the driver head (back side) is also a one type of blind spot.	01
b) State the requirements of passenger seat for ergonomics design.	04
Answer: requirements of passenger seat for ergonomics design (Any Four) 1. Proper seat cushion is provided like polyurethane material. 2. Proper space should be provided for the free movement of leg and hands which is useful to reduce stress. 3. The seat should be adjustable in height and till. 4. The seat should be proper seat like seat belt so that during collision the passenger should not move forward 5. The seat should be providing gradual, gentle and easy landing of the passenger. 6. The seat should be provide with head rest, back rest, arm rest and another cushion part to reduce the stress while long journey 7. It should be low cost. 8. The seat feature includes ergonomically shape to support spine.	01 Mark each

c) Give four aerodynamic properties.	04
Answer: Aerodynamic properties 1. Lift: it is component of force which is perpendicular to air flow. 2. Drag: it is the component of force which is parallel to air flow. 3. Pitching: it is the rotating action produced in the vehicle about transverse axis which is parallel to the ground. 4. Side forces: it is the lateral wind component of a force.	01 Mark each
d) What is the effect of side forces and yaw moment on vehicle performance?	04
Answer**:** Effect of side forces and yaw moment on vehicle performance: **Side forces**: Side force is lateral wind component of a force. It acts into the side of the vehicle. It depends upon the size and shape of the vehicle and nature of the wind. When the vehicle run on road, it comes in contact with the side forces. The side forces are acts into the center of the vehicle. The aerodynamic shape and even steering system characteristics affect the performance of the vehicle. **Yaw moment:** Lateral forces acts on the side of the vehicle which is nor mid of the wheel base, which produces the yawing moment. This affects the steering stability and control which reduces power, velocity and indirectly reduces the vehicle efficiency or performance.	02 02
e) Describe the development of aerodynamics with example.	04
Answer: Development of aerodynamics: Aerodynamics is nothing but study of forces and motion of an object through the fluid. The fluid may water or air. The study is useful to improve the performance of the vehicle by changing the shape and size of the vehicle. In recent years the design is not a major factor to be considered by manufacturers and customers. But after some time the aero dynamist (engineers) had keep focus on the different parameters like various resistance e. g. air resistance etc. Following are the development of aerodynamics: 1588: in war between Spain & England by a ship power, suddenly drag is become problem. 1901: first prototype of wind tunnel was built by Wright brothers to test different wings & airfoils. 1922-23: the engineer's works on development of air streamline. 1951: H. Julian allen introduced concept of blunt body 1990: a vehicle with a body like air ship was built by count ricoti.	02 02

f) What is the effect of cross wind on the tractor with trailer while in motion?	4
Answer: Effect of cross wind on the tractor with trailer while in motion. When the tractor trailer combination is subjected to the cross wind, yawing moment developed on both pulling and trailer. The yawing moment (N_1) is produce on pulling vehicle and yawing moment (N_2) acts on trailer. The trailer is however counteract the yawing moment of the tractor through the trailer coupling which is tends to turn the vehicle in to the cross wind. The resultant rear side force on the pulling tractor can be surprised the driver and may initiate in an appropriate steering correction. Frictional area of trailer is much higher than the pulling vehicle so drag is increased. Initially pulling the vehicle is turned away from the wind. When the wind gust fades away this process is repeated in the opposite direction. The drag of a tractor trailer combination can be about three times that of the tractor alone.  Figure: driving with trailer	03 01

3. Attempt **any two** of the following :	16
a) Describe with sketch flow field around the car with respect to i) air flow pattern ii) pressure distribution.	08
Answer: Flow field around the car: **Air flow pattern:** When the vehicle moves on the road, the air flows over the vehicle. When the speed of the vehicle being increase then the speed of air is also increased. The atmospheric air flows over and down or under the vehicle whenever the air come in contact with body and velocity of air is zero at point, this point is known as stagnation point. The stagnation point is on the frontal area. Due to stagnation point the air flow divided i.e. up to the hood and under the vehicle. The air flow is separated at corner of the front hood. Due to separation some air goes in the wind screen and some of them go side of vehicle. The air flowing on hood by increase velocity and decrease in pressure.	02
 Figure: Air Flow Pattern	02
Pressure distribution: An air flows around a vehicle, a pressure is build up whenever the velocity of air flow decreases. The static pressure is simple as of atmospheric pressure. The dynamic pressure produced by the relative velocity is constant for all stream lines of vehicle. The Bernoulli's equation states that the static + dynamic pressure of the air wind is constant and approached the car. Thus the total pressure is same for all stream line by experimentally we can measure pressure which is positive or negative with respect to atmospheric pressure. On the front face, the stagnation point is formed on the nose of the vehicle. At the front end of the hood,	02

negative pressure is developed where air flow rising over the stagnation point. When the air flow over the hood which is smooth and inclined to wind screen. The boundary layer is start from the stagnation point when the air flows over the wind shield which has some inclination with load. Due to inclination the velocity of moving air is decrease at pressure on wind shield is increases and produce positive pressure.  Fig : Pressure distribution	02
b) What is 'Wind tunnel'? Describe with sketch construction and working of large Full Scale wind tunnel.	08
Answer: **Wind tunnel:** A wind tunnel is a tool used in aerodynamic research to study the effects of air moving past solid objects. It Accurately simulate the fluid flow about vehicles and Measure Forces, moments, pressure, shear stress, heat transfer, flow field (velocity, pressure, temperature. **Construction :** The large full scale is a double-return tunnel capable of moving air at speeds up to 118 miles per hour (190 km/h) through its circuit. It had a 30 ft by 60 ft (9.1 m x 18.3 m) open	02 02

throat, which is capable of testing aircraft with spans of 40 ft (12.2 m).The wind tunnel is a double-return, atmospheric pressure tunnel. A large wind tunnel consists of a closed tubular passage with the object under test mounted in the middle. **Working:** A powerful fan system moves air past the object, the fan must have straightening vanes to smooth the airflow. The test object is instrumented with a sensitive balance to measure the forces generated by airflow or, the airflow may have smoke or other substances injected to make the flow lines around the object visible. It Measure Forces, moments, pressure, shear stress, heat transfer, flow field (velocity, pressure, temperature. It is used for testing of aircraft and rotorcraft, including high-lift development for subsonic transports, V/STOL powered lift, high angle-of-attack for fighter aircraft and propulsion systems.	02
 Figure: Schematic diagram of large Full Scale wind tunnel	02
c) What is aerodynamic drag? Describe the factors affecting aerodynamic drag.	08
Answer: **Aerodynamic drag**: When a solid body is moved through a fluid (gas or liquid), the fluid resists the motion. The object is subjected to an aerodynamic force in a direction opposed to the motion which is called as drag.	02

The factors affecting aerodynamic drag: 1. The object (shape & size) 2. Motion of the air (velocity and inclination of flow) 3. The air (mass, viscosity, compressibility) 1. The Object Geometry has a large effect on the amount of drag generated by an object. As with lift, the drag depends linearly on the size of the object moving through the air. The cross-sectional shape of an object determines the form drag created by the pressure variation around the object. The three dimensional plan form shape affects the induced drag of a lifting wing. If we think of drag as aerodynamic friction, the amount of drag depends on the surface roughness of the object; a smooth, waxed surface produces less drag than a roughened surface. This effect is called skin friction and is usually included in the measured drag coefficient of the object. 2. Motion of the Air Drag is associated with the movement of the aircraft through the air, so drag depends on the velocity of the air. Like lift, drag actually varies with the square of the relative velocity between the object and the air. The inclination of the object to the flow also affects the amount of drag generated by a given shaped object. If the object moves through the air at speeds near the speed of sound, shock waves are formed on the object which create an additional drag component called wave drag. The motion of the object through the air also causes boundary layers to form on the object. A boundary layer is a region of very low speed flow near the surface which contributes to the skin friction. 3. Properties of the Air Drag depends directly on the mass of the flow going past the aircraft. The drag also depends in a complex way on two other properties of the air: its viscosity and its compressibility. These factors affect the wave drag and skin frictions which are described above.	02 02 02
4. Attempt **any four** of the following :	16
a) What are the local origins of flow field around a car body?	04
Answer: Local origins of flow field around a car body: **Front end**: Front end of the car can be roughly approximately as a square block. The streamlines around a car as shown in fig. The flow is significantly deflected at the intersection between the front face and hood. Some air goes side of the vehicle and some goes below or	01

above the vehicle. Due to this pressure increases at front side and increases total drag. This amount of drag also depends on the edge radius and hood inclination.

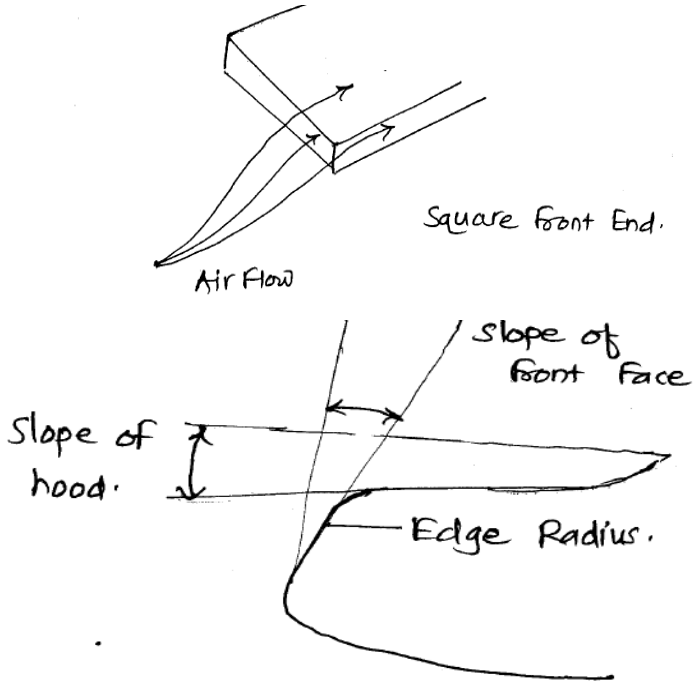


Fig: local origin of flow field -Front end

Wind shield wiper and pillar

Flow separation will occur in following areas

a) At A base of wind shield
b) At a top of windshield
c) At a pillar

Following parameters affect on the drag

a) Radius and inclination of the pillar
b) Wind shied inclination

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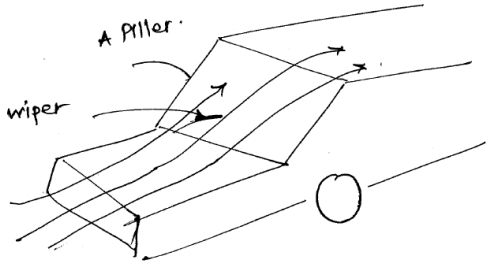

Fig: local origin of flow field - Wind shield wiper and pillar

Roof:

The drag coefficient can be reduced by arching the roof in longitudinal direction as shown in fig.

The favorable effect of the arching depends upon sufficient large bend radius at the junction between windshield and roof so that negative pressure at this location does not large. The design of the roof in such a way that there should not be any change in the frontal area of the car.

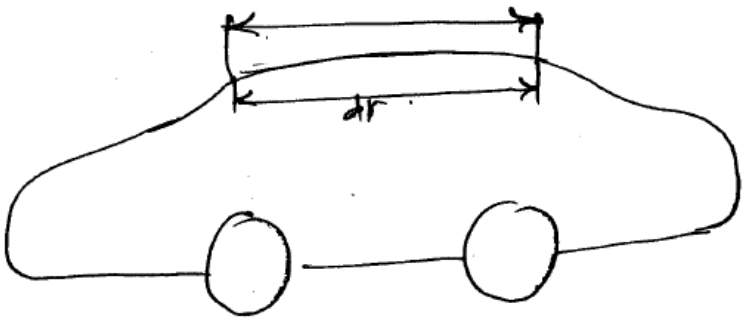

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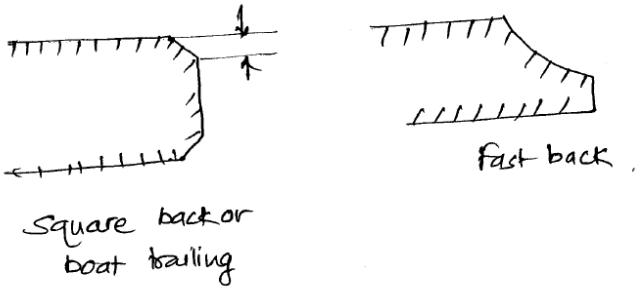
Fig: Roof

Rear end:

Three types of rear ends can be used for the cars like square back, fast back, and notch back. There is more drag in case of square back as Compared to fast back and notch back.



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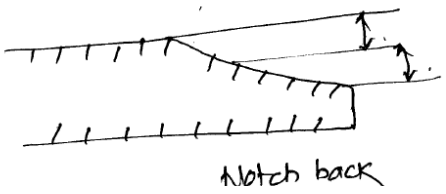


Fig : Types of Rear End

b) Describe the sources of wind noise.	04
Answer: Sources of wind noise: There are three wind noise sources are as follows a) Leak noise b) Cavity noise c) Wind rush noise etc. **Leak Noise** It is caused by presence of direct flow path which connect to the exterior part of the vehicle to the passenger compartment. The air pressure usually lowers at the outside of the car than inside and the pressure difference causes air flow out of leak at high velocity. Actually leak flow is usually smaller leaks which is due to the unsteady pressure on the outside of automobile. If the leak is present leak noise will almost dominates the other wind noise sources. **Cavity Noise** Even if there are no direct leaks the presence of cavities on the vehicle exterior can cause wind noise. If the cavity is located in a region of high velocity flow such as pillar area or around the outside rear views mirror he cavity noise is produced. Common cavity noise sources are the gaps around the doors, the exposed gaps on the outside rear view mirror and gaps in the radiator grilled area. **Wind rush** This is generated by the fluctuating pressure on the exterior of the vehicle caused by the flow of the air over the surface.	01 01 01 01
c) What are the designs features of outside rear view mirror in vehicle aerodynamics?	04
Answer: Designs features of outside rear view mirror: (Any four) 1. Body of the mirror must be provided with minimum surface irregularities so as to minimize the wind noise levels. 2. Exterior overall shape of the mirror must be carefully designed so as to minimize the wind noise. 3. Mirrors must be foldable so as to reduce the overall width of the car. 4. Mirror attachments provided in such a way that there should not be any disturbances. 5. Sharp edge should be minimized and rounded pattern.	01 Mark each

d) What do you mean by directional stability? State the factors the aerodynamic stability.	04
Answer: Directional stability of the vehicle: Directional stability is stability of a moving body or vehicle about an axis which is perpendicular to its direction of motion. Stability of a vehicle concerns itself with the tendency of a vehicle to return to its original direction in relation to the oncoming medium (water, air, road surface, etc.) when disturbed (rotated) away from that original direction. Factors affecting on directional stability of the vehicle: (Any four) a) Tyre inflation pressure b) Steering geometry c) Steering system d) Shape of the vehicle e) Air flow around the vehicle f) Road condition g) Tyre condition h) Weight of the vehicle i) Side forces	02 02
e) In case of light motor vehicle, how does the weight distribution affects the aerodynamic stability?	04
Answer: Lift, drag, side forces as well as pitching, yawing, rolling moments are important factors as vehicles aerodynamics stability concerned. There should not be any change on a vehicle due to this forces and moments called as aerodynamic stability of the vehicle. Generally light motor vehicle having FERWD. In this, rear portion of the vehicle can be used for the loading purpose. Aerodynamic stability of the vehicle also depends on the amount as well as fashion of loading of the vehicle. In this case maximum load on the front side of the vehicle. due to air resistance , there is a lift from front side of the vehicle which reduces the load on the front wheel decreases it will increases the sensitivity of the steering response and vehicle become unstable. In this case maximum load on the rear side of the vehicle. When vehicle climbing the hill at that time front wheel load decreases and increases the sensitivity of the steering response and vehicle becomes unstable. As compared to case first and second chances of instability of the vehicle is less.	04

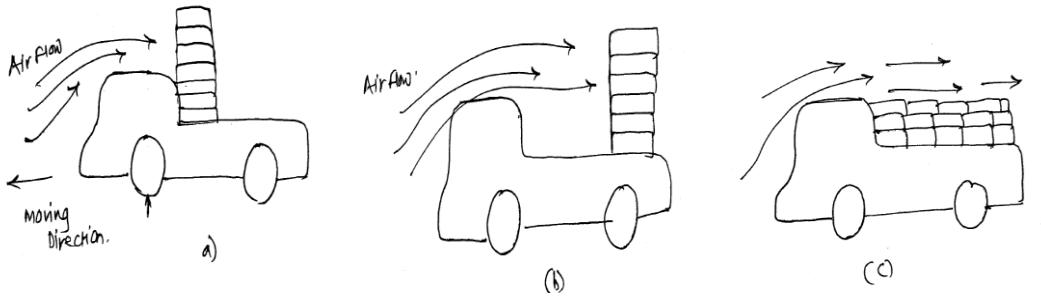


Fig : Fashion of Vehicle loading and weight distribution

f) Classify car bodies with example. — 04

Answer: Classification of Car bodies:**(**Classification 02 Marks , Example 2 Marks**)** — 04

Closed Cars:

a) Sedan car: A sedan car (American English) or saloon car is a passenger car with two rows of seats and adequate passenger space in the rear compartment for adult passengers.

Example: The vehicle usually has a separate rear trunk (boot in British English) for luggage, although some manufacturers such as Chevrolet and Volkswagen have made rear-engine models.

b) Hatchback: Saloon with a door at the back.

Hatchback (a.k.a. lift back) sedans typically have the fastback profile, but instead of a trunk lid, the entire back of the vehicle lifts up (using a lift gate or hatch).A vehicle with four passenger doors and a lift gate at the rear can be called a four-door hatchback, four-door hatchback sedan, or five-door sedan.

Example: TATA Indigo

c) Coupe: Saloon with roofline at decreased height. One row of seats for two person only two doors is provided.

Example: Hyundai gnesis, Jagwar F type

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

Example: Mercedes GL450 54"

Open Cars:

a)Sports: Two door or less, provided with a collapsible hood

Example: Ferrari

b)Convertible: Foldable Type Roofs, But wind up windows

Example: BMW 3-Series 320i, BMW 3-Series 325i

Special Cars:

a)Estate Car:

Saloon Car, Passenger roof extended right up to rear end.

More luggage space & longer wheel base. Estate Cars or Station Wagons are family cars with an extended rear boot area. Offering more cargo capacity than a standard sedan, they are a popular alternative to a family car.

Example: Volkswagen Passat SW

b) Station Wagon: Wood paneled body, and it has same look like steel structure.

Example: Audi A4

5. Attempt **any two** of the following :	16
a) Derive the expression for stability of vehicle on turn.	08

Answer: Expression for stability of vehicle on turn.

Let a vehicle take a turn to the left a shown in fig.

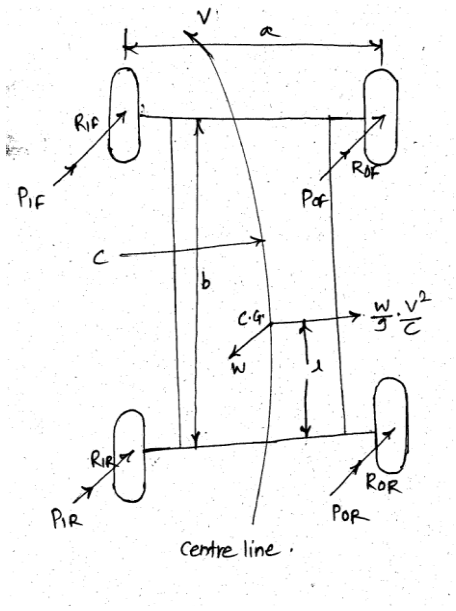


Fig: Stability of vehicle on turn. 02

C= radius of curved path measured at c.g. of the vehicle ,m

r= road wheel radius

a= wheel track, m.

b= wheel base, m

h= height of the c.g. in front of rear axle axis, m

V = linear speed of the vehicle on the road. m/s

W= Weight of the vehicle , N

Reactions at the wheels due to the weight

let R_{IF} and R_{IR} be the normal reactions at the inner front and rear inner wheels respectively and R_{OF} and R_{OR} be the normal reactions at the outer front and outer rear wheels respectively

$$R_{IF} + R_{OF} = \frac{Wl}{b}$$

$$R_{IR} + R_{OR} = W\left(1 - \frac{1}{b}\right)$$

$$R_{IF} = R_{OF}$$

$$R_{IR} = R_{OR}$$

$$R_{IF} = R_{OF} = \frac{Wl}{2b}$$

$$R_{IR} = R_{OR} = \frac{W}{2}\left(1 - \frac{1}{b}\right)$$

02

Reactions at the wheels due to centrifugal force

The centrifugal force acts outwards through C.G. of the vehicle with magnitude $= \frac{W}{g}\frac{V^2}{C}$. This produces a horizontal reaction that constitutes a couple $\left(= \frac{W}{g}\frac{V^2}{C}h\right)$ tending to overturn the vehicle. This couple is balance by vertical reactions at the wheels which are downward at the two inner wheels and upward at two outward wheels as shown in fig.

02

If P_{IF} &P_{OF} are the inner and outer normal reactions at the front wheels and simultaneously P_{IR} &P_{OR} for the rear wheels then $P_{IF} + P_{IR} = P_{OF} + P_{OR} = \frac{W}{g}\frac{V^2}{C}\frac{h}{a}$ $P_{IF} = P_{OF} = \frac{Wl}{2b}\frac{V^2}{gC}\frac{h}{a}$ $P_{IR} = P_{OR} = \frac{W}{g}\left(1-\frac{1}{b}\right)\frac{V^2}{gC}\frac{h}{a}$ **Reactions at the wheels due to gyroscopic effect** when the vehicle takes a turn the gyroscopic effect appears a) Due to Precession of rotating wheels and other parts either rotating the engine speed or the wheel speed but parallel the plane of rotation of the wheel b) Due to the precession of engine parts and also others are rotating either at engine or wheel speed but perpendicular to the plane of rotation of the wheel. The Axes of rotation of the a) and b) are horizontal. $I_{f=}$ moment of inertia of the rotating parts of the engine (Faster moving) N-m^2 $I_{s=}$ moment of inertia of the rotating parts of the engine (Slower moving) N-m^2	02
b) A vehicle of gross weight 40 kN is held at rest on slope of 10^0 It has a wheel base if 2.5 m and its centre of gravity is 1.2 m above the ground level and 0.8 m in front of the rear axle. Calculate i) Normal reaction at the wheels ii) Angle of slope so that vehicle will being to slide when breaks are applied and if μ= 0.35 iii)Angle of slope so that the vehicle will overturn	08
Solution: Given θ= 10^o b=2.5m h= 1.2m	

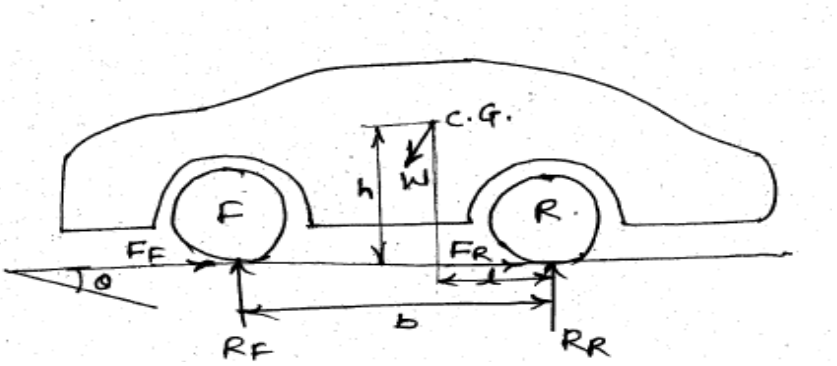


Fig : Wheel Reactions

i) Normal reaction at the wheels

$R_F + R_R = W\cos\theta$

$=40000\cos\emptyset$

$=39392.310N$

$R_R = \frac{w}{b}A[(b - 1cos\theta - hsin\theta)]$ 04

$=\frac{40000}{2.5}[(2.5 - 1)cos10 - 1.2sin10]$

$=16000[1.5\cos 10 - 1.2sin10]$

$=16000[1.2688]$

$=20300.8N$

$R_F=39392.310-20300.8$

$=19091.51N$

ii) Angle of slope so that vehicle will being to slide when breaks are applied and if μ= 0.35 02

$\tan\theta L=\mu=0.35$

$\theta = tan^{-1}(0.35)$ =19.29 $=19^0 17'$ **iii) Angle of slope so that the vehicle will overturn** $\tan\theta L=(b-\lambda)/h$ $=(2.5-0.8)/1.2$ = 1.4166 $Tan^{-1}(1.41166)$ =54 $=54^0 46'$	02
c) A truck weighing 60kN has to run with a maximum speed 80 km/hr in top gear. If the total resistant $R=k_rW+K_a AV^2N$, Coefficient of rolling resistance = 0.018, Coefficient of air resistance = 0.0276 and Frontal area = 5.564 m^2 the transmission efficiency in top gear of 6.2 :1 is 90 % and in second gear of 15:1 is 80 % . Calculate i) Engine brake power required ii) Engine speed if the driving wheels have an effective diameter of 0.8125 m. iii) The maximum grade the truck can negotiate. iv) Maximum draw bar pull available.	08
Solution: **i) Engine brake power required** $R=0.018W + 0.0276Av^2$ $= 0.018(60000) + 0.0276 \times 5.564(80)^2$ =2062.8249N Engine B.P=$\frac{RV}{1000nt}$ $=\frac{2062.8249 \times 80}{1000 \times 0.9 \times 3.6}$ **B.P.**=50.933N	02

ii) Engine speed if the driving wheels have an effective diameter of 0.8125 m.

$V=\frac{2\pi Nr}{G}$ m/min

$n=\frac{VG}{2\pi r}=\frac{80\times1000}{60}\times\frac{6.2}{2\pi\times040625}$ 02

=3238.59r.p.m.

iii) The maximum grade the truck can negotiate.

$V=\frac{80}{15}\times 6.2$

=33.06km/hr

$R=0.018\times(60000)+0.0276\times5.564(33.06)^2$

= 1247.842N

It can climb the maximum grade pf I in x

$R=\left[1247.842+\frac{60000}{N}\right]^N$ 03

$F=\frac{b.p\times nt\times1000}{v}$

$=\frac{50.933\times0.8\times1000\times3.6}{33.06}$

=4436.994N

$247.842+\frac{60000}{x}=4436.994$

X=18.81

maximum grade I in 18.81

iv) Maximum draw bar pull available.

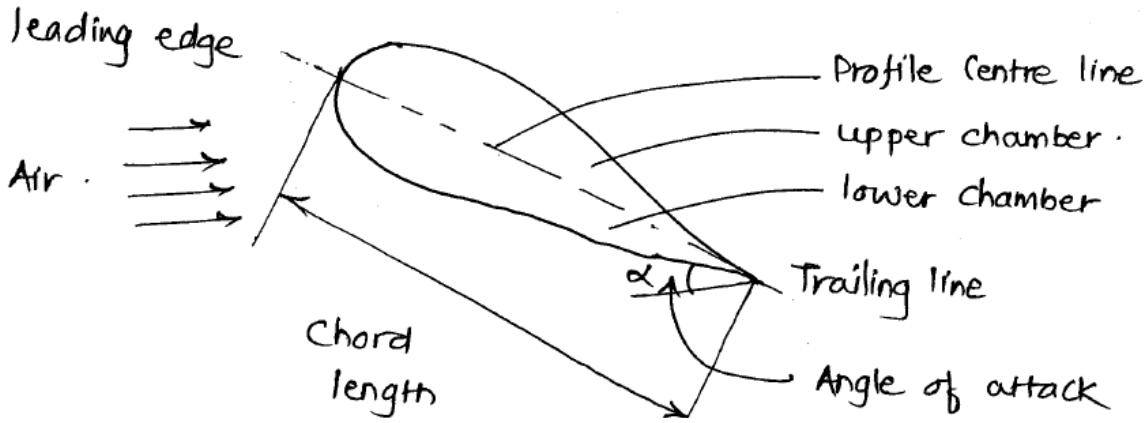
= Tractive effort available –tractive effort for resistance on level

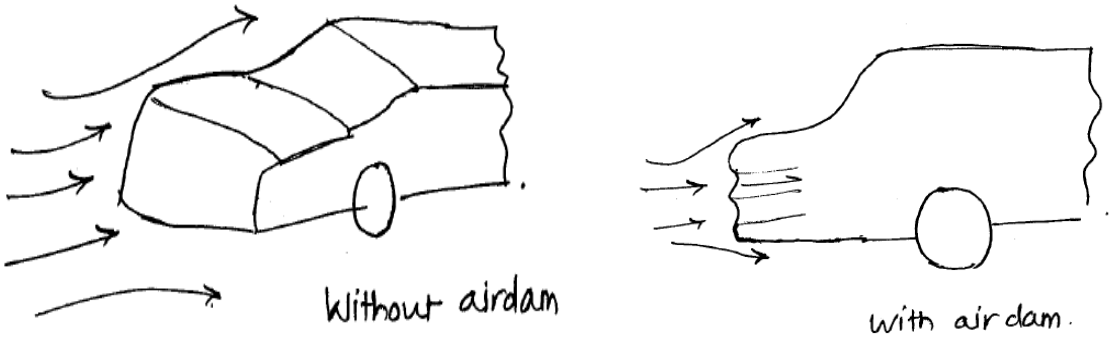
=4436.994-1247.8442 01

=3189.152

6. Attempt **any four** of the following :	16
a)What are the resistances faced by the vehicle while in motion?	04
Answer: When the vehicle moves on the road then the some factor which to be opposes the motion of the vehicle is called resistance. Following are some types of resistance 1. Rolling resistance 2. Air resistance 3. Gradient resistance 1) Rolling resistance- Resistance offered by the vehicle due to friction between tyre and surface of road is called as rolling resistance. Rolling resistance depends upon the weight of vehicle, tyre surface and road surface. Road resistance can be calculated by $Rr=K_rW$ Where Kr=coefficient of rolling resistance W=weight of vehicle Rr=rolling resistance 2) Air or wind resistance: When vehicle offered the resistance due to air then it is called as air or wind resistance. It is depend upon speed of the vehicle, size and shape of the body of vehicle. Air resistance can be calculated by $Ra=K_aV^2$ Where ,k=coefficient of resistance A=forward projected area V= speed of vehicle 3) Gradient resistance It is the force opposing forward motion of a vehicle up to gradient called gradient resistance. This resistance does not depend upon the speed of vehicle.	01 01 01 01

Gradient resistance can be calculated by - Gr=W/θ Where, θ =gradient W=weight of vehicle Gr=gradient resistance	
b) Describe how road performance of a vehicle is related to acceleration.	04
Answer: When the vehicle is accelerated, its rotating parts are also accelerated depending upon their moments of inertia and the gear ratio in the drive line. Due to this, weight of vehicle is increased from W to W_e. This increased weight (We) is called the effective weight of the vehicle. When surplus power, i.e., surplus tractive effort is fully utilized to acceleration, then Surplus or excess power=We f =V/3600 Kw or, maximum acceleration (f) f=1x (surplus power) x3600/(We x V) =(1 x (Pe- Preq) x ηt x3600)/V =1 X(Pe x ηt –Pv) x 3600/V =(Tractive effort –Road resistance)/We =(F-R)/W_e	02 02
c) Describe the terms gradibility and drawbar pull.	4
Answer: **Gradeability**: It is the maximum percentage grade negotiated by vehicle under full rated condition is known as Gradibility. Gradibility=100/W(tractive effort-road resistance) =100/W(F_t-R_t) **Drawbar pull**- when the excess power is fully utilized for pulling extra load attached to the vehicle then it is called as draw bar pull. Maximum drawbar pull = tractive effort – road resistance	02 02

Maximum Drawbar pull = F_t - R_t But $R_t = R_a + R_r$ Where R_a = air resistance R_r = rolling resistance F_t = ractive effort R_t = road resistance	
d) What is meant by air foil and air dam?	04
Answer: **Air foil:** The overall shape of a car bodies has developed from the profile of wing or airfoil as shown in figure. In aerodynamic development of automobile the air foil shape is used because of it has very low drag. It is a shape of wing or blade(of propeller or turbine). An air foil shape body move through a fluid produces a forces perpendicular to the motion called lift. e.g. fixed wings, air craft horizontal and vertical stabilization are build with air foil shape as are helicopter motor blade. Airfoils are more efficient lifting shape able to generate more lift and less drag. In airfoil the length of leading edge to the length of tailing edge called chord length. The angle between the chord edge to the horizontal is known as angle of attach  **Fig : air foil** . **Air dam:** Air dam is used in many commercial vehicles .Air dam is a rigid skirt like panel that is placed below the front bumper. When the vehicle is in moving condition, air dam diverts air up and over the hood, into the grille opening and around. Some air is used to cool the engine, front brakes. It gives direction to air flow. It also reduces the amount of air flowing underneath the vehicle which reduces aerodynamic lift. This result in less lift on front end, less drag less under hood pressure. It increases front end stability and improve high speed	02 02

cornering grip.  **Fig: Air dam and Air Flow**	
e) What are the types of aerodynamic drag?	04
Answer: Types of aerodynamic drag (Any Four) **1) Total drag:** This is formally defined as the force corresponding to the rate of decrease in momentum in the direction of the undisturbed external flow around the body. There are a number of separate contributions to total drag. As a first step it may be divided into **pressure drag** and **skin-friction drag.** **2) Skin- friction drag (or surface- friction drag)** This is the drag that is generated by the resolved components of the traction due to the shear stresses acting on the surface of the body **3) Pressure drag** This is the drag that is generated by the resolved components of the forces due to Pressure acting normal to the surface at all points. **4) Induced drag (or vortex drag)** Induced drag depends on lift, does not depend directly on viscous effects, and can be estimated by assuming inviscid flow. **5) Wave drag** This is the drag associated with the formation of shock waves in high-speed flight. **6) Form drag (or boundary-layer pressure drag)** This can be defined as the difference between the profile drag and the skin-friction drag	01 Mark for Each

f) How vehicle speed is related to engine speed?	04
Answer: The power developed inside the engine by combustion of fuel is called as engine power. But that power is loss in friction and other types of losses. Therefore the speed of engine is not equal to speed of vehicle N/V ratio depends upon the overall gear ratio, Where, N=engine revolution V= vehicle speed(km/h) A vehicle having four different gears will have four different values of N/V ratios .It is expressed in $2\Pi rN/G=1000V/60$ $N/V=1000G/(2\Pi r)(60)$ $N/V=2.65\ G/r$ Where, G = overall gear ratio.	04