## Type: DES

Q1. List the different types of pillars used in vehicles. Mention the function of each one. (2)

Q2. With the aid of a neat sketch, compare the "Kamm back", "Long back" and "Blunt back" designs of the rear body. (3)

Q3. A one-tenth-scale model of an airplane is to be tested at 20°C in a pressurized wind tunnel. The prototype is to fly at 240 m/s at 10-km standard altitude. At the altitude of 10 km, the temperature is -50°C and air density is 0.4 kg/m<sup>3</sup>. What should the tunnel pressure be in "kPa" to scale both the Mach number and the Reynolds number accurately? Use the Table 1 for the required data. (5)

Table 1. Air properties at Standard Pressure

т, с	$\rho$ , kg/m <sup>3</sup>	$\mu$ , N · s/m <sup>2</sup>	$\nu$ , m <sup>2</sup> /s	<i>T</i> , F	$\rho$ , slug/ft <sup>3</sup>	$\mu$ , lb $\cdot$ s/ft <sup>2</sup>	$\nu$ , ft <sup>2</sup> /s
-40	1.52	1.51 E-5	0.99 E-5	-40	2.94 E-3	3.16 E-7	1.07 E-4
0	1.29	1.71 E-5	1.33 E-5	32	2.51 E-3	3.58 E-7	1.43 E-4
20	1.20	1.80 E-5	1.50 E-5	68	2.34 E-3	3.76 E-7	1.61 E-4
50	1.09	1.95 E-5	1.79 E-5	122	2.12 E-3	4.08 E-7	1.93 E-4
100	0.946	2.17 E-5	2.30 E-5	212	1.84 E-3	4.54 E-7	2.47 E-4
150	0.835	2.38 E-5	2.85 E-5	302	1.62 E-3	4.97 E-7	3.07 E-4
200	0.746	2.57 E-5	3.45 E-5	392	1.45 E-3	5.37 E-7	3.71 E-4
250	0.675	2.75 E-5	4.08 E-5	482	1.31 E-3	5.75 E-7	4.39 E-4
300	0.616	2.93 E-5	4.75 E-5	572	1.20 E-3	6.11 E-7	5.12 E-4
400	0.525	3.25 E-5	6.20 E-5	752	1.02 E-3	6.79 E-7	6.67 E-4
500	0.457	3.55 E-5	7.77 E-5	932	0.89 E-3	7.41 E-7	8.37 E-4

Q4. What are the requirements for accurate functioning of wind tunnel balances? (5)

Q5. What is induced drag? How does it affect the total drag for different car families? (3)

Q6. Based on the direction of flow, distinguish between the types of flow separation on bluff bodies. (2)

Q7. Illustrate the interaction of the C-pillar vortex pair with the vortex from the separation bubble in the cases of the fastback, notchback and square-back cars. (5)

Q8. A tennis ball with a mass of 57 g and a diameter of 6.4 cm is hit with an initial velocity of 105 km/h and a backspin of 4200 rpm. Determine if the ball falls or rises under the combined effect of gravity and lift due to spinning shortly after hitting. Assume air is at 1 atm and 25°C. (3)



Figure 1 Drag and Lift characteristics for flow across spheres with air properties

Q9. On what factors does the size of the separation bubble at the base of the front windshield depend? (2)

Q10. What modifications can be carried out on the roof of vehicles to reduce drag? (2)

Q11. How does the hood and front-end inclination affect the drag of cars? (3)

Q12. Applying Buckingham Pi-theorem to air flow across objects, derive the dimensionless numbers characterizing the flow. (5)

Q13. What is Hysteresis Loss in vehicles? Enumerate the factors affecting this loss. (3)

Q14. Explain the different elements of a wind-tunnel in detail. (5)

Q15. With a neat sketch, show the development of a boundary layer on a thin flat plate. (2)