AERODYNAMICS
(MECH 3238)

Time Allotted : 3 hrs   **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and
__any 5 (five)__ from Group B to E, taking __at least one__ from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

    (i)   The main branch associated with design of combustion in furnaces, wind load on buildings and structures etc. is known as
            (a) Aeronautical aerodynamics   (b) Aerodynamics of turbo-machinery
            (c) Industrial aerodynamics   (d) Environmental aerodynamics.

    (ii)   The flow of liquid from one point to another point is known as
            (a) Hydrodynamics   (b) Gas dynamics
            (c) Aerodynamics   (d) both (a) and (b).

    (iii)   (Inertia force) / (pressure force) is known as
            (a) Euler number   (b) Mach number
            (c) Reynolds number   (d) Froude number.

    (iv)   If Mach number satisfy the relation $0.8 < M < 1$, then the corresponding flow is called
            (a) subsonic   (b) transonic
            (c) supersonic   (d) hypersonic.

    (v)   _____ is transverse oscillations of some structures due to the development of aerodynamic forces which are in phase with the motion.
            (a) Galloping   (b) Flutter
            (c) Ovalling   (d) Both Flutter and ovalling

    (vi)   Automotive aerodynamics is the study of the aerodynamics of
            (a) road vehicles   (b) water vehicles
            (c) air vehicles   (d) both water and air vehicles.

    (vii)   Strength of the vortex tube remain _____ along the tube.
            (a) uniform   (b) non uniform
            (c) both uniform and non uniform   (d) none of the above

(viii)   Sudden reduction in _____ force may be observed due to wing stall.
(a) lift   (b) drag
(c) centrifugal   (d) coriolis

(ix)   Increase in lift force without any change in relative wind, is associated with
(a) decrease in camber   (b) decrease in chord
(c) decrease in span   (d) increase in angle of attack.

(x)   Shear stress reversal may take place due to flow _____.
(a) stagnation   (b) non-uniformity   (c) separation   (d) uniformity.

Group- B

2.   (a)   Write the expressions of pressure coefficient and skin friction coefficient.
[(CO1)(Remember/LOCQ)]
(b)   On a physical intuitive basis, the resultant aerodynamics force depends on which parameters?   [(CO1)(Understand/LOCQ)]
(c)   Consider an infinitely thin flat plate of chord c at an angle of attack α in a supersonic flow. The pressures on the upper and lower surfaces are different but constant over each surface; that is $p_u(s) = c_1$ and $p_l(s) = c_2$, where c_1 and c_2 are constants and $c_2 > c_1$. Ignoring the shear stress, calculate the location of the centre of pressure.   [(CO2)(Analyze/IOCQ)]
2 + 4 + 6 = 12

3.   (a)   Write the significance of dimensional analysis and flow similarity in aerodynamic fields.   [(CO1)(Understand/LOCQ)]
(b)   Consider an infinitely thin flat plate with a 1 m chord at an angle of 8º in a supersonic flow. The pressure and shear stress distributions on the upper and lower surfaces are given by
$$p_u = 4 \times 10^4 (x-1)^2 + (5 \times 10^4), \quad p_l = 2 \times 10^4 (x-1)^2 + (1.7 \times 10^5), \quad \tau_u = 290 x^{-0.2} \text{ and } \tau_l = 730 x^{-0.2}$$
respectively, where x is the distance from the leading edge in meters, p and τ are in N/m^2. Calculate normal and axial forces, the lift and drag, all per unit span.
[(CO2)(Analyse/IOCQ)]
6 + 6 = 12

Group - C

4.   (a)   Establish the relation $\psi = -\dfrac{\Gamma}{2\pi} \ln r$, where the symbols have their usual meanings.
[(CO3)(Remember/LOCQ)]
(b)   An open circular cylinder of 20 cm diameter and 100 cm long contains water up to a height of 80 cm. It is rotated about its vertical axis. Find the speed of rotation when: (i) no water spills, (ii) axial depth is zero.
[(CO3)(Analyze/IOCQ)]
6 + 6 = 12

5. (a) Explain Kelvin's circulation theorem and Biot-Savart law.
[(CO1)(Understand/LOCQ)]
   (b) Analyze the Magnus effect and the Joukowski's transformation.
[(CO3)(Analyze/IOCQ)]
6 + 6 = 12

Group - D

6. (a) What is the difference between streamlined and blunt bodies? Is a tennis ball a streamlined or blunt body? [(CO4)(Analyze/IOCQ)]
   (b) What is the difference between skin friction drag and pressure drag? Which is usually more significant for slender bodies such as airfoils?
[(CO4)(Analyze/IOCQ)]
6 + 6 = 12

7. (a) A kite may be regarded as equivalent to a rectangular aerofoil of 800 mm chord and 1.5 m span. When it faces a horizontal wind of 15m/s at 15° to the horizontal the tension in the guide rope is 80 N and the rope is at 15° to the vertical. Calculate the lift coefficient, assuming an air density of 1.2 kg/m^3.
[(CO4)(Evaluate/HOCQ)]
   (b) The drag coefficient of a vehicle increases when its windows are rolled down or its sunroof is opened. A sports car has a frontal area of 1.6 m^2 and a drag coefficient of 0.3 when the windows and sunroof are closed. The drag coefficient increases to 0.4 when the sunroof is open. Determine the additional power consumption of the car when the sunroof is opened at 80km/h. Take the density of air to be 1.2 kg/m^3. [(CO4)(Evaluate/HOCQ)]
6 + 6 = 12

Group – E

8. (a) How a shock wave created ahead of the wing's leading edge, interacts with wing & body of an aircraft? [(CO5)(Understand/LOCQ)]
   (b) Explain how the knowledge of aerodynamics applicable in the design of pumps blades. [(CO4)(Analyse/IOCQ)]
6 + 6 = 12

9. (a) Compare automotive aerodynamics and aircraft aerodynamics.
[(CO1)(Remember/LOCQ)]
   (b) Explain effect of wind on structure based on static and dynamic loading.
[(CO2)(Understand/LOCQ)]
6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	37.5	50	12.5

Course Outcome (CO):

After the completion of the course students will be able to

CO1: Describe the fundamental laws of aerodynamics.
CO2: Relate the fundamental laws to solve problems in aerodynamic applications.
CO3: Solve standard bench mark problems like vortex flow, Stokes theory, etc.
CO4: Analyze the effect of drag and lift force on aerofoils.
CO5: Estimate the compressibility effects on swept wings.
CO6: Design various aerodynamic structures like turbo machinery blades, vehicles, buildings, etc.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question