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 aircrafts, missiles, space vehicles etc. is known as
(a) Aeronautical aerodynamics (b) Aerodynamics of turbo-machinery
(c) Industrial aerodynamics (d) Environmental aerodynamics.

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

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

(iv) If Mach number satisfy the relation $1<M<1.2$, then the corresponding flow is called
(a) subsonic (b) transonic
(c) supersonic (d) hypersonic.

(v) Flow of liquid inside the impeller of a centrifugal pump is an example of
(a) free vortex flow (b) forced vortex flow
(c) no vortex flow (d) both (a) and (b).

(vi) _____ is a line whose tangent is everywhere parallel to the local vorticity vector.
(a) Stream line (b) Vortex line
(c) Path line (d) Streak line

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

(viii) 'Stall' is sudden and rapid decrease in _____ force.
(a) drag (b) lift (c) body (d) aerodynamic

(ix) Kutta–Joukowski theorem relates lift to _____.
(a) vorticity (b) drag (c) circulation (d) velocity potential

(x) For dynamic effects of wind building or structure with a height to minimum lateral dimension ratio of more than about
(a) 5 (b) 10 (c) 15 (d) 20.

Group- B

2. (a) Explain centre of pressure of an aerofoil. What is the significance of the following relation? $M_{LE} = \frac{C}{4}L + M_{c/4}$. *[(CO1)(Understand/LOCQ)]*

(b) Consider an infinitely thin flat plate of chord c at an angle of attack 10° in a supersonic flow. The pressures on the upper and lower surfaces are different but constant over each surface; that is $p_u(s)=p_1$ and $p_l(s)=p_2$, where p_1 and p_2 are constants and $p_2 > p_1$. Ignoring the shear stress, calculate the location of the centre of pressure. *[(CO2)(Evaluate/HOCQ)]*

6 + 6 = 12

3. (a) Discuss effects of subsonic, transonic and supersonic flow in aerodynamic fields. *[(CO1)(Understand/LOCQ)]*

(b) Consider an infinitely thin flat plate with a 1 m chord at an angle of 9° in a supersonic flow. The pressure and shear stress distributions on the upper and lower surfaces are given by
$p_u = 5\times10^3(x-1)^2 + (5\times10^4)$, $p_l = 3\times10^3(x-1)^2 + (1.7\times10^5)$, $\tau_u = 300x^{-0.2}$ and $\tau_l = 700x^{-0.2}$ respectively, where x is the distance from the leading edge in meters, p and τ are in N/m^2. Calculate the lift force per unit span. *[(CO2)(Evaluate/HOCQ)]*

6 + 6 = 12

Group - C

4. (a) Explain with neat sketch of vortex sheet and write practical application of it. *[(CO3)(Analyze/IOCQ)]*

(b) In a free cylindrical vortex flow of water, at a point at a radius of 150mm, the velocity and pressure are 5 m/s and 15 N/cm^2 respectively. Find the pressure at a radius of 300 mm. *[(CO3)(Evaluate/IOCQ)]*

6 + 6 = 12

5. (a) Explain vortex tube and vortex line with neat sketch. *[(CO3)(Analyze/IOCQ)]*

(b) A cylinder rotates at 150 rpm with its axis perpendicular in an air stream which is having uniform velocity of 25 m/s. The cylinder is 1.5 m in diameter and 10 m long. Assuming ideal fluid theory, find (i) the circulation and (ii) lift force. Take the density of air as 1.25 kg/m^3. *[(CO3)(Evaluate/HOCQ)]*

6 + 6 = 12

Group – D

6. (a) What do you understand by streamlined body? Can a streamlined body act like a bluff body? *[(CO4)(Understand/LOCQ)]*

   (b) How the geometrical shape of an object influence the resultant drag force acting on it? *[(CO4)(Analyze/IOCQ)]*

6 + 6 = 12

7. (a) A 2 cm outer diameter pipe is to span across a river at a 20m wide section while being completely immersed in water. The average flow velocity of water is 5m/s and the water temperature is 20°C. Determine the drag force exerted on the pipe by the river. Given the density of water at 20°C is 999 kg/m^3 and Coefficient of drag C_D = 1.1. *[(CO4)(Evaluate/HOCQ)]*

   (b) Explain how finite wing span produces induced drag? *[(CO4)(Analyze/IOCQ)]*

6 + 6 = 12

Group – E

8. (a) What do you understand by Bow shock? Also give an example. *[(CO5)(Understand/LOCQ)]*

   (b) Explain how the knowledge of aerodynamics applicable in the design of pump hub and impeller eye. *[(CO4)(Analyse/IOCQ)]*

6 + 6 = 12

9. (a) Write the different features of aerodynamics vehicles. *[(CO6)(Remember/LOCQ)]*

   (b) Discuss the different reasons of dynamic component which essentially causes the oscillation of structure. *[(CO6)(Understand/IOCQ)]*

6 + 6 = 12

Cognition Level	*LOCQ*	*IOCQ*	*HOCQ*
Percentage distribution	*31*	*44*	*25*

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.*