AERODYNAMICS
(MECH 3238)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) The main branch associated with design of missiles, aircraft, space vehicles, hovercraft 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) $[(\text{Inertia force}) / (\text{pressure force})]^{0.5}$ is known as
(a) Froude number
(b) Reynolds number
(c) Mach number
(d) Euler number

(iv) If Mach number satisfy the relation $0.8<M<1.2$, then the corresponding flow is called
(a) Subsonic
(b) Transonic
(c) Supersonic
(d) Hypersonic

(v) Flow of fluid in a centrifugal pump casing is an example of
(a) Free vortex flow
(b) Forced vortex flow
(c) Mixed vortex flow
(d) Both (a) and (b)

(vi) A material volume that moves with the fluid in such a manner that the vorticity vector remains tangent to the surface of the tube is called
(a) Stream tube
(b) Vortex tube
(c) Ordinary hollow tube
(d) Solid tube

(vii) Direction of lift force is perpendicular to the
(a) Wind velocity
(b) Relative wind velocity
(c) Object velocity
(d) Chord line

(viii) What is the dimension for drag coefficient?
(a) N/s
(b) m/s
(c) Dimensionless
(d) kg/N

(ix) In the expression $\psi = -\frac{\Gamma}{2\pi}\ln(r)$, ψ is known as
(a) Potential function
(b) Stream function
(c) Velocity
(d) Acceleration

(x) Flow over _____ bodies is prone to flow separation.
(a) Streamlined
(b) Bluff
(c) Airfoil
(d) both (a) and (c)

Fill in the blanks with the correct word

(xi) Sudden reduction in _____ force may be observed during wing stall.

(xii) The function of Pitot tube is to measure the _____ at any point on the flowing fluid.

(xiii) For a steady, 2D and incompressible flow, stream function must exist at every point in the flow field irrespective of whether the flow is _____ or not.

(xiv) Equipotential lines are _____ to streamlines.

(xv) Geometric similarity means similarity of _____.

Group - B

2. (a) Write a short note on centre of pressure of an aerofoil. *[(CO1)(Remember/LOCQ)]*
(b) Explain the significance of fundamental aerodynamic variables. *[(CO1)(Analyse/IOCQ)]*

6 + 6 = 12

3. (a) An aeroplane approaches to land at a speed of 40 m/s at sea level. A 1/5 th scale model is tested under dynamically similar conditions in a compressed air tunnel working at 10 atmosphere and 15˚C. It is found that the load on the tailplane is subject to impulsive fluctuations at a frequency of 20 cycles per second, owing to eddies being shed from the wing-fuselage junction. If the natural frequency of flexural vibration of the tailplane is 8.5 cycles per second, could this represent a dangerous condition? *[(CO2)(Evaluate/HOCQ)]*

(b) Write the significance of Mach number regimes for transonic and hypersonic flows. *[(CO1)(Analyse/IOCQ)]*

8 + 4 = 12

Group - C

4. (a) Draw and explain streamlines and potential lines for a free vortex flow. *[(CO3)(Analyse/IOCQ)]*

(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 maximum speed of rotation when no water spills. *[(CO3)(Evaluate/HOCQ)]*

6 + 6 = 12

5. (a) Establish Kutta-Joukowski equation for lift force acting on rotating cylinder. *[(CO3)(Apply/IOCQ)]*

(b) A cylinder whose axis is perpendicular to the stream of air having a velocity of 20 m/s, rotates at 300 rpm. The cylinder is 2 m in diameter and 10 m long. Find the circulation and theoretical lift force per unit length. *[(CO4)(Evaluate/IOCQ)]*

6 + 6 = 12

Group - D

6. (a) Using a proper diagram show the meaning of the NACA 4412 aerofoil. *[(CO4)(Analyze/IOCQ)]*

(b) With the help of suitable diagrams, explain the difference between streamlined and blunt bodies? *[(CO4)(Analyze/IOCQ)]*

6 + 6 = 12

7. (a) 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 m2 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 1.2kg/m3. *[(CO4)(Evaluate/HOCQ)]*

(b) Consider an aircraft, which takes off at 200km/h when it is fully loaded. If the weight of the aircraft is increased by 20 percent as a result of overloading, determine the speed at which the overloaded aircraft will take off. *[(CO4)(valuate/HOCQ)]*

7 + 5 = 12

Group - E

8. (a) Briefly describe the aerodynamic effects of sweep angle on aircraft wings. *[(CO5)(Analyse/IOCQ)]*

   (b) Explain how the knowledge of aerodynamics applicable in the design of turbine guide vanes. *[(CO6)(Analyse/IOCQ)]*

6 + 6 = 12

9. (a) What is Automotive aerodynamics? Compare automotive aerodynamics and aircraft aerodynamics. *[(CO6)(Analyse/IOCQ)]*

   (b) Explain the effect of wind on structure, based on static, dynamic and aerodynamic loading. *[(CO4)(Analyse/IOCQ)]*

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	6.25	66.67	27.1

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.*