

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:

$12 \times 1 = 12$

Choose the correct alternative for the following

- (i) (Inertia force) / (pressure force) is known as
 - (a) Froude number
 - (b) Reynolds number
 - (c) Mach number
 - (d) Euler number
- (ii) If Mach number satisfy the relation $1.2 < M < 5$, then the corresponding flow is called
 - (a) Subsonic
 - (b) Transonic
 - (c) Supersonic
 - (d) Hypersonic
- (iii) Flow of fluid in a centrifugal pump casing is an example of
 - (a) Free vortex flow
 - (b) Forced vortex flow
 - (c) No vortex flow
 - (d) Both (a) and (b)
- (iv) Kutta - Joukowski theorem states that _____ per unit span on a two dimensional body is directly proportional to the circulation around the body.
 - (a) Drag
 - (b) Lift
 - (c) Lift and drag both
 - (d) None of the above
- (v) The lift force $F_L = \rho L U \Gamma$, here Γ means
 - (a) Free stream velocity
 - (b) Density of fluid
 - (c) Circulation
 - (d) Specific weight
- (vi) Bodies with a larger cross section will have
 - (a) Lower drag
 - (b) Higher drag
 - (c) Same drag
 - (d) No drag
- (vii) Direction of lift force is perpendicular to the
 - (a) Wind velocity
 - (b) Relative wind velocity
 - (c) Object velocity
 - (d) Chord line
- (viii) Streamlined bodies have lower _____ while moving through air.
 - (a) Lift
 - (b) Drag
 - (c) Speed
 - (d) Fuel efficiency

(ix) Compressibility effect is significant for fluid flow where _____.
 (a) $M < 0.1$ (b) $M < 0.2$ (c) $M < 0.3$ (d) $M > 0.3$

(x) Frictional force of aerodynamic drag increases significantly with the vehicle _____.
 (a) Weight (b) Speed (c) Colour (d) All of the above

Fill in the blanks with the correct word

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

(xii) Kinematic similarity means similarity of _____.

(xiii) In the expression $\psi = -r/2\pi \ln r$, ψ is known as _____ function.

(xiv) The function of manometer is to measure the _____ difference between any two points.

(xv) Equipotential lines are _____ to streamlines.

Group - B

2. (a) Prove that at any instant of time the value of the stream function remain unchanged along a streamline. $[(CO2)(Analyse/IOCQ)]$
 (b) The velocity potential function, ϕ is given by $\phi = x^2 - y^2$.
 Find (i) the velocity components in x and y direction
 (ii) Also show that ϕ represents a possible case of fluid flow
 (iii) Find the velocity components at the point (4,5). $[(CO2)(Apply/IOCQ)]$

6 + 6 = 12

3. (a) If for a 2D potential flow, the velocity potential is given by $\phi = 4x(3y-4)$, determine the velocity at the point (2,3). Determine also the value of stream function ψ at the point (2,3). $[(CO2)(Apply/HOCQ)]$
 (b) Write short notes on circulation and vorticity. $[(CO1)(Remember/LOCQ)]$

6 + 6 = 12

Group - C

4. (a) Explain the application of Magnus effect in practical field. $[(CO3)(Apply/HOCQ)]$
 (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, (ii) lift force. [Take density of air as 1.25 kg/m^3]. $[(CO3)(Apply/HOCQ)]$

6 + 6 = 12

5. (a) For free vortex flow prove that the tangential velocity is inversely proportional to a radial distance. $[(CO3)(Analyse/IOCQ)]$

(b) Prove that $\phi = -\frac{\Gamma}{2\pi} \ln r$, where the symbols have their usual meanings.

[(CO3)(Analyse/LOCQ)]

6 + 6 = 12

Group - D

6. (a) What is 'Terminal Velocity'? Explain with a suitable sketch. *[(CO4)(Understand/LOCQ)]*
 (b) What do you understand by 'irrotational flow'? *[(CO4)(Understand/LOCQ)]*

6 + 6 = 12

7. (a) Explain the mechanism of generation of lift-induced drag on a finite-span airfoil? *[(CO43)(Analyse/LOCQ)]*
 (b) What is flow separation? How does it bring aerofoil wings to a stall condition? *[(CO4)(Understand/LOCQ)]*

6 + 6 = 12

Group - E

8. (a) What is Automotive aerodynamics? Compare automotive aerodynamics and aircraft aerodynamics. *[(CO6)(Analyse/LOCQ)]*
 (b) How a shock wave created of the wing's leading edge, interacts with wing and body of an aircraft? *[(CO5)(Analyse/HOCQ)]*

6 + 6 = 12

9. (a) What do you understand by Bow shock? Also give an example. *[(CO5)(Analyse/LOCQ)]*
 (b) How does the sweep angle of a 2-dimensional wing affect its aerodynamic performance, including lift, drag, and stall characteristics? *[(CO5)(Understand/LOCQ)]*

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	31.25	43.75	25

