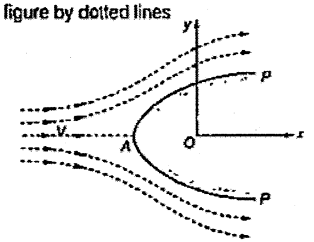
14 CHAPTER

External Flow : Drag and Life

Q.1 A Rankine (oval) hall body *PP* is subjected to a two dimensional flow with uniform velocity *V*, resulting in typical streamlines as shown in the figure by dotted lines



The point A on the body surface is
(a) separation point
(b) stall point
(c) stagnation point
(d) point of maximum velocity

Q.2 With the same cross-sectional area and immersed in same turbulent flow, the largest total drag will be on a
(a) a circular disc or plate held normal to flow
(b) a sphere
(c) a cylinder
(d) a streamlined body

Q.3 In which of the following the friction drag is generally larger than pressure drag?
(a) A circular disc or plate held normal to flow
(b) A sphere
(c) A cylinder
(d) An airfoil

Q.4 Drag force in a function of
(a) projected area of the body
(b) mass density of the fluid
(c) velocity of the body
(d) All of these

Q.5 A streamlined body is defined as a body about which
(a) the flow is laminar
(b) the flow is along the streamlines
(c) the flow separation is suppressed
(d) the drag is zero

Q.6 The lift formula given by
Lift = $\rho V_0 \Gamma$
where ρ is density of the fluid, V_0 is free stream velocity and Γ circulation would be valid for
(a) two dimensional steady flow
(b) incompressible flow
(c) body of any shape
(d) All of these

Q.7 A circular cylinder is rotated in anticlockwise direction and an ideal fluid flows perpendicular to its axis in horizontal direction. The cylinder will experience
(a) drag in horizontal direction of flow
(b) lift in vertically downward direction
(c) lift in vertically upward direction
(d) No lift

Q.8 The drag force experienced by an object is
(a) the vertical component of the resultant fluid dynamic force acting on the object
(b) the horizontal force due to pressure variation over the surface of the object
(c) the component of the resultant fluid dynamic force in the flow direction
(d) the resultant fluid dynamic force acting on the object

Q.9 In Stoke's law for drag on small spheres, the ratio of pressure drag to shear drag is

(a) 2 (b) $\frac{1}{2}$

(c) $\frac{1}{3}$ (d) 3

Q.10 Superposition of circulation of strength τ on uniform flow of velocity *U*, normal to a circular cylinder of radius a, produces a surface velocity (V_θ) as

(a) $2U\sin\theta + \frac{\tau a}{2\pi}$ (b) $2U\sin\theta - \frac{\tau a}{2\pi}$

(c) $2U\sin\theta + \frac{\tau}{2\pi a}$ (d) $2U\sin\theta - \frac{\tau}{2\pi a}$

Q.11 What is the ratio of the lift coefficient to drag coefficient of an airfoil section at stall?
(a) 1.5 (b) 3
(c) 15 (d) 30

Q.12 Magnus effect may be used advantageously in games such as cricket, tennis, table tennis and golf. In order to obtain a lift i.e., a rising curve for the trajectory of the ball, from left to right, the nature of the spin to be given is
(a) anticlockwise in the vertical plane
(b) anticlockwise in the horizontal plane
(c) clockwise in the vertical plane
(d) clockwise in the horizontal plane

Q.13 Match List-I (Predominant drag) with List-II (Motion of) and select the correct answer using the codes given below the lists:

List-I
A. Deformation drag
B. Surface drag
C. Form drag

List-II
1. A wing of an airplane
2. An air bubble in honey
3. A rain drop
4. A parachute
5. A cricket ball

Codes:

	A	B	C
(a)	2,3	5	1,4
(b)	2	1,3	4,5
(c)	1	2,3	4,5
(d)	1	2,3,5	4

Q.14 Various objects and Reynolds number (R_D) of flow past them are given in List-I. List-II contains the drag coefficients of these bodies. Match List-I with List-II and select the correct answer using the codes given below the lists:

List-I
A. Long circular cylinder normal to the flow $R_D = 10^5$
B. Long circular cylinder normal to the flow $R_D > 5 \times 10^5$
C. Sphere, $R_D = 5 \times 10^5$
D. Long rectangular plate, $R_D > 10^3$

List-II
1. 2.00
2. 1.20
3. 0.33
4. 0.20

Codes:

	A	B	C	D
(a)	2	3	4	1
(b)	3	2	1	4
(c)	2	3	1	4
(d)	3	2	4	1

Q.15 Match List-I (Body) with List-II (Drag coefficient) and select the correct answer using the codes given below the lists :

List-I
A. Airfoil ($R_D > 10^7$)
B. Sphere ($10^4 < R_e < 10^5$)
C. Flat plate perpendicular to flow ($R_e > 10^3$)
D. Droplet ($R_e = 0.1$)

List-II
1. 240
2. 1.90
3. 0.50
4. 0.003

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	4	3	1	2
(c)	4	3	2	1
(d)	4	1	3	2

Q.16 Consider the following statements:

1. Friction and pressure drag depends upon the shape and position of immersed body
2. If a thin plate is kept parallel to direction of flow, then the pressure drag is zero
3. If a thin plate is kept perpendicular to the moving fluid, then friction drag is zero

Which of these statements is/are correct?

(a) Both 1 and 3 (b) Only 3
(c) Both 1 and 2 (d) 1, 2 and 3

Q.17 Deformation drag

1. exists when viscous forces are much more predominate than inertia forces
2. mainly exists in very small objects moving at very small velocity through fluids of high viscosity
3. exists for higher values of Reynold's number

Which of these statements is/are correct?

(a) Only 3 (b) Both 1 and 2
(c) Both 1 and 3 (d) 1, 2 and 3

Q.18 An aeroplane having a wing span of 16 m and chord of 2.5 m weighs 11 tonnes. If it gets airborne at a velocity of 300 kmph, then the coefficient of lift is nearly

(a) 0.0004 (b) 0.0006
(c) 0.4 (d) 0.65

Q.19 A sphere of certain diameter, when towed submerged under water, experiences a drag force of 4 Newtons at a velocity of 1.5 m/s. If another sphere of twice the diameter of the sphere referred as above, is towed with the same velocity in water, the drag force experienced by this sphere will be

(a) 8 N (b) 16 N
(c) 24 N (d) 32 N

Q.20 In the stoke's experiment of falling sphere, it is found that a sphere of 5 mm diameter falls in a liquid with terminal velocity 20 mm/s giving a drag coefficient of 240. The ratio of specific gravities is 2.65. Which one of the following is the kinematic viscosity of the liquid in stokes?

(a) 3.5 (b) 10.0
(c) 225.0 (d) 1000.0

Q.21 A ping-pong ball, having a diameter of 3.6 cm and weighing 2.4 *g*, is served with a horizontal velocity of 10 m/sec and a spin that gives rise to coefficient of lift of 0.2. Assuming the density of air to be 0.00129 *g*/cc, the lift experienced by the ball is nearly

(a) 13 *g* (b) 1.3 *g*
(c) 0.13 *g* (d) 0.013 *g*

Q.22 A 1 m wide and 3 m long flat plate, held stationary, parallel to the flow direction of a uniform incoming stream of water of velocity 3 m/s, leaves a velocity profile, at its trailing edge, varying linearly from zero at the plate to the free-stream velocity of 3 m/s at 5 cm away from the plate. The water flow is only on one side of the plate. Assuming the pressure to be the same everywhere in the flowing water, the drag force on the plate will be

(a) 75 N (b) 66.7 N
(c) 62.5 N (d) 56.25 N

Q.23 Match List-I with List-II and select the correct answer using the codes given below the lists:

List-I

A. Singing of telephone wires
B. Velocity profile in a pipe is initially parabolic and then flatterns
C. Formation of cyclones
D. Shape of Rotameter tube

List-II

1. Vortex flow
2. Drag
3. Vortex shedding
4. Turbulence

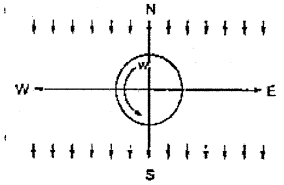
Codes:

	A	B	C	D
(a)	3	1	4	2
(b)	2	1	4	3
(c)	3	4	1	2
(d)	2	4	1	3

Q.24 Assertion (A): The 'dimples' on a golf ball are intentionally provided.
Reason (R): A turbulent boundary layer, since it has more momentum than a laminar boundary layer can better resist an adverse pressure gradient.

(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.25 A circular cylinder held in a uniform flow from north to south as shown in the figure, is rotated about its own axis in the anticlockwise direction. It will experience a lift force in the direction of



(a) N (b) S
(c) E (d) W

Q.26 An object has a projected area of 1 m^2 normal to the direction of flow and 2 m^2 in the direction of flow. It has a drag coefficient of 0.4 for a Reynold's number of 10^7. The drag force (in kN) on body over a characteristic length of 2.45 m when moving through water at 20°C will be
[Take $\mu = 9.8 \times 10^{-4}$ N-s/m^2]

(a) 3.20
(b) 6.40
(c) 31.26
(d) 62.72

Q.27 Assertion (A): When a cylinder is placed in a rectilinear flow with its axis perpendicular to flow, no drag force is exerted in an ideal fluid flow.
Reason (R): The flow net and hence pressure distribution is symmetrical about a diametrical plane perpendicular to the flow.

(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

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Answers **External Flow : Drag and Life**

1. (c)	2. (a)	3. (d)	4. (d)	5. (c)	6. (d)	7. (b)	8. (c)	9. (b)	10. (c)
11. (c)	12. (d)	13. (b)	14. (a)	15. (c)	16. (d)	17. (b)	18. (d)	19. (b)	20. (b)
21. (b)	22. (d)	23. (c)	24. (a)	25. (d)	26. (b)	27. (a)			

12. (d)

For rising curve for the trajectory of the ball, lift force in the vertical plane is needed. So for left to right trajectory, clockwise rotation should be given in horizontal plane.

17. (b)

Deformation drag exists for very small value of Reynold's number ($R_e = 0.2$)

18. (d)

$$C_L = \frac{F}{A\rho\frac{V^2}{2}}$$

$$= \frac{11\times 1000\times 9.81\times 2}{(16\times 2.5)1.2\left(\frac{300\times 1000}{3600}\right)^2} = 0.65$$

19. (b)

$$\frac{F_{D_2}}{F_{D_1}} = \frac{D_2^2}{D_1^2}$$

Therefore, if the diameter of the sphere becomes twice,

$$F_{D_2} = F_{D_1}\times\left(\frac{2D_1}{D_1}\right)^2$$

$$= 4\times F_{D_1}$$

$$= 4\times 4$$

$$= 16\,N$$

20. (b)

$$C_D = \frac{24}{R_e}$$

$$R_e = \frac{VD}{\nu}$$

gives $\nu = 10^{-3}\ m^2/s$

$= 10^{-3}\times 10^4$ stokes

$= 10$ stokes

21. (b)

Lift force,

$$F_L = \frac{1}{2}C_L g\rho A V^2$$

$$= \frac{1}{2}\times 0.2\times(1000)^2\times 0.00129\times\frac{\pi(3.6)^2}{4}$$

$$= 1.313\,g$$

26. (b)

Velocity corresponding to Reynold's number of 10^7 is calculated by

$$R_e = \frac{\rho VL}{\mu}$$

$$\Rightarrow \quad V = \frac{R_e\mu}{\rho L}$$

$$\Rightarrow \quad V = \frac{10^7\times 9.8\times 10^{-4}}{1000\times 2.45} = 4\ m/s$$

(Max. projected area is considered)

∴Drag on the object,

$$F_D = \frac{1}{2}\times C_D\times\rho\times A\times V^2$$

$$= \frac{1}{2}\times 0.4\times 10^3\times 2\times 4^2$$

$$= 6.4\ kN$$

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