1.32. What is the bulk modulus of a liquid that has a density increase of 0.02% for a pressure increase of 0.6 MPa.

1.33. If K (*bulk* modulus of water) = 2.2 GPa. What pressure is required to reduce its volume by 0.5%.

1.34. A steel container expands in volume by 1% when the pressure within it is increased by 70 MPa. At standard pressure of 101.325 kPa, it holds 450 kg water, ρ = 1000 kg/m^3, K = 2.06 GPa when it filled, how many kg mass of water need to be added to increase the pressure to 70 MPa.

1.35. A water-droplet is formed when its inside pressure is 0.002 bar higher than outside air pressure. Determine the diameter of water droplet formed. Take σ = 0.075 N/m for water with air.

1.36. A liquid drop of radius R breaks up into 64 smaller drops all are of equal size. Prove that the work done is given by

$$W = 12\pi \sigma R^2.$$

Where σ is the surface tension between the liquid and air.

1.37. A tube of 2 mm in diameter is dipped vertically into a container containing mercury. The lower end of the tube is 2 cm below the mercury surface. Find the pressure of air supplied to the tube to blow a hemispherical bubble at the lower end. σ (mercury) = 0.4 N/m. (**Ans.** Δp = 3468 Pa)

1.38. A soap bubble of 3 cm diameter is formed when its inside pressure is 2N/m^2 above atmosphere. Find the surface tension of the soap bubble.

1.39. Air is introduced through a nozzle into a tank of water to form a stream of air bubbles of 2 mm diameter. Calculate by how much pressure in the nozzle must exceed that of surrounding water. Take σ = 0.073 N/m. (**Ans.** Δp = 143.4 Pa)

1.40. At a depth of 8 km below the surface of ocean, the pressure is 82 MN/m^2. Determine the density of sea water at this depth if the density at the surface is 1025 kg/m^3 and K (*bulk* modulus) = 2350 MN/m^2 for this pressure range. Calculate also the percentage change in specific volume and specific gravity. (**Ans.** 1061 kg/m^3, – 3.4% and 3.5%)

1.41. A oiled steel needle floats on a water surface with its cross-section perpendicular to the water surface. The oil prevents the wetting of the needle by water. Neglecting hydrostatic effects, determine the maximum diameter of the needle that can float if the contact angle between the needle and water is 110°. Take specific gravity of steel = 7.8 and σ (surface tension of water) = 0.073 N/m. (**Ans.** 3.93 mm)

OBJECTIVE TYPE QUESTIONS

Identify the Correct Answer

1. The liquid can resist the following stresses :
(*a*) Tensile and compressive (*b*) Tensile and shear
(*c*) Compressive and shear (*d*) All of the above.

2. A real fluid possess which of the following property
(*a*) Viscosity (*b*) Surface tension (*c*) Compressibility (*d*) None of them.

3. The ratio of the specific weight of the liquid to the specific weight of standard fluid is known as
(*a*) Specific volume (*b*) Weight density (*c*) Viscosity (*d*) Specific gravity.

4. Newton's Law of viscosity is given by

(*a*) $\tau = \mu \dfrac{du}{dy}$ (*b*) $\tau = \mu^2 \dfrac{du}{dy}$ (*c*) $t = \mu \dfrac{d^2u}{dy^2}$ (*d*) $\tau = \dfrac{1}{\mu}\dfrac{du}{dy}$.

5. A fluid which does not follow the linear relationship between shear stress and rate of deformation is known as
(*a*) Newtonian fluid (*b*) Non-newtonian-fluid (*c*) Ideal fluid.

6. The viscosity of the gas ________ with increase in Temperature.
(*a*) Increases (*b*) Decreases (*c*) First increases and then decreases
(*d*) First decreases and then increases. (*e*) No effect.

7. Surface tension is caused by a force of ________ at the free surface
(a) Adhesion (b) Cohesion (c) Both a and b (d) None of the above.
8. Which of the following is an example of phenomenon of surface tension
(a) Rain drop (b) Rise of sap in a tree (c) Break up of liquid jet (d) All of the above.
9. The unit of surface tension is
(a) N/m (b) N/m^2 (c) N^2/m (d) N/m^3.
10. The pressure inside a soap bubble above atmosphere is given by
(a) $\Delta p = \frac{4\sigma}{d}$ (b) $\Delta p = \frac{2\sigma}{d}$ (c) $\frac{8\sigma}{d}$ (d) $\frac{\sigma}{d}$.
11. With increase in size of water droplet, the pressure inside the drop
(a) Increases (b) Decreases (c) Remains same (d) Cannot be predicted.
12. Compressibility of a fluid is the reciprocal of
(a) Shear modulus of elasticity (b) Young's modulus of elasticity
(c) Bulk modulus of elasticity (d) Any of the above.
13. Bulk modulus of elasticity is the ratio of
(a) Tensile stress to tensile strain (b) Compressive stress to volumetric strain
(c) Compressive stress to compressive strain (d) None of the above.
14. Newton's law of viscosity for a fluid states that the shear stress is
(a) Proportional to angular deformation
(b) Proportional to rate of angular deformation
(c) Inversely proportional to angular deformation
(d) Inversely proportional to rate of angular deformation.
15. For a fluid, the shear stress was found to be linearly proportional to the rate of angular deformation, the fluid is classified as
(a) Newtonian (b) Non-newtonian (c) Ideal (d) Thixotropic.
16. A fluid has indicated the following shear stress and deformation rates

τ	10	15	20	30
(du/dy)	0	1	2	4

The fluid is classified as
(a) Newtonian (b) Non-newtonian (c) Bingham plastic (d) Dilatant.
17. The following equation can be applied to

$$\tau = C + \mu\left(\frac{du}{dy}\right)^n \text{ where } c \text{ and } n \text{ are constant}$$

(a) Newtonian fluid (b) Non-newtonian fluid (c) Real fluid (d) Thyxotropic fluid.
18. If a relationship of τ (Y-axis) and $\frac{du}{dy}$ (X-axis) is plotted then the behaviour of an ideal fluid is exhibited by
(a) Straight line passing through origin and inclined to X-axis
(b) Along + ve X-axis (c) Along + ve Y-axis (d) A curve passing through origin.
19. The relationship between τ and $\frac{du}{dy}$ for a fluid is a curve passing through origin, then the fluid should be
(a) Newtonian (b) Ideal (c) Non-newtonian (d) Bingham plastic.

20. A relation between τ and $\frac{du}{dy}$ for a fluid is given as

τ	0	1	3	5
$\frac{du}{dy}$	0	8	24	40

The fluid is classified as
(a) Real (b) Ideal (c) Newtonian (d) Non-newtonian.

21. The dimension of μ in terms of M, L and T is given by
(a) $ML^{-1}T^{-1}$ (b) MLT (c) MLT^{-1} (d) $ML^{-1}T$.

22. A clearance between shaft and sleeve is filled with an oil. When a force of 800 N is applied to the shaft parallel to sleeve, shaft moves with a speed of 15 mm/s. If a force applied is 2400 N, then the speed of the shaft will be
(a) 20 mm/s (b) 45 mm/s (c) 120 mm/s (d) 5 mm/s.

23. The kinematic viscosity is given by
(a) μ/ρ (b) $\mu\rho$ (c) ρ/μ (d) $\mu/\rho g$.

24. A dirty sample of water when tested was found that the volume is decreased by 1% with an increase in pressure of 180 bar. The bulk modulus of elasticity of this sample is
(a) 1.8 bar (b) 18000 bar (c) 18 bar (d) 1800 bar.

25. The bulk modulus of elasticity K for a gas at constant temperature is
(a) p (b) p/ρ (c) ρT (d) p/T.

26. If the capillary rise of water in 2 mm diameter tube is 1.5 cm, then the capillary rise in 0.5 mm diameter tube will be
(a) 10 cm (b) 1.5 cm (c) 24 cm (d) 6 cm.

27. If the surface tension between water-air interface is 0.073 N/m then the gauge pressure inside the rain drop of 1 mm diameter is
(a) 73 Pa (b) 146 Pa (c) 14.6 Pa (d) 292 Pa.

28. The pressure inside a soap bubble of 10 mm diameter above atmosphere is
(a) 32 Pa (b) 16 Pa (c) 160 Pa (d) 0.32 Pa.
If surface tension of the soap solution is 0.04 N/m.

29. It is found that the capillary rise is 15 mm when a 3 mm tube is immersed in a liquid. If a tube of 4 mm is immersed in the same liquid, then the capillary rise will be
(a) 11.25 mm (b) 20 mm (c) 8.5 mm (d) 25.76 mm.

30. An apparatus produces water bubbles of 70 μm. The pressure inside the droplet above atmosphere is
(a) 5600 Pa (b) 4000 Pa (c) 13200 Pa (d) 8000 Pa.
when σ (water in air) = 0.07 N/m.

31. A predominant fluid property associated with cavitation is
(a) Surface tension (b) Bulk modulus of Elasticity
(c) Vapour pressure (d) Mass density.

32. σ_{lg} = Surface tension at liquid-gas interface.
σ_{gs} = Surface tension at gas-solid interface.
σ_{ls} = Surface tension at liquid-solid interface.
If a small drop of liquid is formed on the solid surface will remain in equilibrium without spreading it.
(a) $(\sigma_{gs} - \sigma_{ls}) > \sigma_{lg}$ (b) $(\sigma_{lg} - \sigma_{ls}) > \sigma_{gs}$ (c) $(\sigma_{gs} - \sigma_{ls}) < \sigma_{lg}$ (d) $(\sigma_{lg} - \sigma_{ls}) < \sigma_{gs}$.

33. At a liquid-air-solid interface, the contact angle θ measured in the liquid is less than 90°. The liquid is
(a) wetting (b) Non-wetting (c) Ideal (d) Does not form a stable bubble.

34. The rain drops are spherical because of
   (a) Surface tension of water (b) Capillarity of water
   (c) Incompressibility of water (d) None of the above.
35. Mercury cannot wet glass tube because of the property
   (a) Cohesion (b) Adhesion (c) Surface Tension (d) Viscosity.

ANSWERS

1. (c)	2. (d)	3. (d)	4. (a)	5. (b)	6. (a)	7. (b)	8. (d)	9. (a)
10. (c)	11. (b)	12. (c)	13. (b)	14. (b)	15. (a)	16. (c)	17. (d)	18. (b)
19. (c)	20. (c)	21. (a)	22. (b)	23. (a)	24. (b)	25. (a)	26. (d)	27. (d)
28. (a)	29. (a)	30. (b)	31. (c)	32. (c)	33. (a)	34. (a)	35. (c).	

State whether the following statements are TRUE or FALSE :

1. An ideal fluid is that fluid which obeys Newton's law of viscosity.
2. Viscosity of dirty water is higher than rain water.
3. Viscosity of gas increases with an increase in temperature.
4. Density of liquid = Specific gravity of liquid × density of water.
5. Free surface of liquid acts like an elastic membrane due to surface tension.
6. Capillarity is due to combined effect of adhesion and cohesion.
7. Capillary rise or fall does not depend upon specific weight of liquid.
8. Vapour pressure of liquid-drop falls with increase in temperature of liquid.
9. The statement **"Flow must be laminar but velocity distribution can be either linear or non-linear"** if it is related to Newton's law of viscosity.
10. State the values of C_1, C_2 and n in the equation

$$\tau = C_1 \left(\frac{du}{dy}\right)^x + C_2$$

If the fluid is (i) Newtonian (ii) Non-newtonian (iii) Ideal.

11. Saving-steel-blade float on water when surface is kept flat but sinks when dropped to right angle to it.
12. State the characteristic of fluid property in the following phenomena.
   (i) Rise of Sap in a tree.
   (ii) Rain water drop is spherical.
   (iii) Cavitation.
   (iv) The flow of oiljet without break-up.

ANSWERS

1. F	2. T	3. T	4. T	5. T	6. T	7. F	8. F	9. F

10. (i) $n = 1, C_2 = 0$ (ii) $n \neq 0, C_2 = 0$ (iii) $C_1 = C_2 = 0$.
11. Free surface behaves as a membrane
12. (i) Capillarity (ii) Surface tension (iii) Vapour pressure (iv) Viscosity.

OBJECTIVE TYPE QUESTIONS

Identify the Correct Answer

1. The value of normal atmospheric pressure is
   (a) 76 cm of Hg (b) 10.33 m of water (c) 1.01325 bar (d) All the above.
2. According to Pascal's Law, pressure at any point in a liquid
   (a) is different in different directions (b) is same in all directions
   (c) is same only along horizontal (d) is same only along vertical direction.
3. If h_{Hg} represents the pressure head in meters of mercury then the equivalent water head in meters is
   (a) $\frac{h_{Hg}}{13.6}$ (b) $\frac{13.6}{h_{Hg}}$ (c) $13.6\, h_{Hg}$ (d) None of the above.
4. Pressure intensity in water at a level of 10 m below the free surface of water is
   (a) 981 Pa (b) 98.1 kN/m^2 (c) 9810 Pa (d) None of the above.
5. Manometer is used to measure
   (a) Only moderate pressure (b) Only low pressure (c) Only negative pressure (d) All the above.
6. The pressure head of a liquid whose specific weight is ω (N/m^3) and pressure intensity is p (N/m^2) is given by
   (a) $\frac{p}{\omega}$ (b) $\frac{\omega}{p}$ (c) ωp (d) None of the above.
7. The basic differential equation for the variation of pressure p in a static fluid with vertical distance h (measured upward) is
   (a) $dp = -\omega\, dh$ (b) $dp = -dh$ (c) $dp = -\frac{dh}{\omega}$ (d) $dp = -\omega dh$.
8. Bourdon gauge measures
   (a) Absolute pressure (b) Gauge pressure
   (c) Local atmospheric pressure (d) Standard atmospheric pressure.
9. When barometer reads 74 cm of Hg, a pressure of 10 kPa suction at that location is equivalent to
   (a) 10.02 m of water (ab_s) (b) 9.87 m of water (ab_s) (c) 88.53 kPa (ab_s) (d) 0.043 kPa (ab_s).
10. The standard atmospheric pressure is 760 mm of Hg. At a certain location, barometer reads 710 mm of Hg. At that location, an absolute pressure of 360 mm of Hg. Corresponds to a gauge pressure in mm of Hg.
    (a) 400 mm (b) 350 mm (c) 360 mm (d) 710 mm.
11. A U-tube manometer measures
    (a) Absolute pressure at a point (b) Local atmospheric pressure
    (c) Difference in pressure between two points (d) Difference in total energy between two points.
12. The standard atmospheric pressure is 101.32 kPa. The local atmospheric pressure at that location was 91.52 kPa. If the pressure recorded is 22.48 kPa (gauge), it is equivalent to absolute pressure
    (a) 123.8 kPa (b) 88.84 kPa (c) 114 kPa (d) 69.04 kPa.
13. A glass U-tube made of 8 mm diameter contains mercury upto 10 cm from its bottom. If 19 cm^3 of water is added to one of the limbs, the difference in mercury level will be
    (a) 3 cm (b) 2.8 cm (c) 1.0 cm (d) None of the above.
14. Differential manometer is used to measure
    (a) Pressure difference between two points in the same pipe line
    (b) Pressure difference between two pipes
    (c) Pressure difference between two pipes, provided they contain same liquid
    (d) All the above.

15. The manometric liquid used in inverted differential manometer should have

(a) High density (b) Low density (c) High surface tension (d) Low surface tension.

16. Pressure head difference (h) between two points in a pipe line is given by

(a) $H = h\left(\dfrac{S_m}{S} - 1\right)$ (b) $H = h\left(\dfrac{S}{S_m} - 1\right)$ (c) $H = h\left(\dfrac{S_m - 1}{S}\right)$ (d) $H = h\left(\dfrac{S - 1}{S_m}\right)$.

where h is difference of level of manometric liquid and S_m is the specific gravity and S is specific gravity of liquid flowing through the pipe.

17. Any pressure measured above absolute zero is known as

(a) Atmospheric pressure (b) Absolute pressure

(c) Gauge pressure (d) None of the above.

18. The fundamental unit of pressure N/m^2 is known as

(a) Pascal (b) Poise (c) Stoke (d) None of the above.

19. A piezometer tube is not suitable to measure

(a) Positive pressure (b) Negative pressure (c) Atmospheric pressure (d) None of the above.

20. Which of the following is used to measure the pressure difference between two pipes carrying same liquid or different liquids.

(a) Piezometer (b) Single column manometer

(c) Differential manometer (d) None of the above.

21. A mercury manometer used for measuring pressure difference indicates 50 cm head of Hg. This pressure difference in meters of water will be

(a) 0.63 m (b) 6.3 m (c) 6.8 m (d) 0.68 m.

ANSWERS

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

3.74. A concrete gravity dam is in the form of a right angled triangle in section. Its height is 12 m towards its vertical side and base is 8 m. Determine the resultant force acting on the dam taking unit length of the dam when the dam contains water upto 10 m and point of action on the floor. Also find out the maximum and minimum stresses developed on the base of the dam.
Take $S_m = 2.5$.

3.75. A masonary wall of 7 m high and 3 m wide retains water upto 6 m height. Find the magnitude and direction of the resultant force considering the width of wall is unit. Also find out the point of action of resultant force at the base of the wall and maximum and minimum stresses at the base of the wall. Take $S_m = 2.5$.

3.76. Water stands against a vertical wall 45 cm thick and 4 m high. The resultant thrust cuts the horizontal base at a distance 6 cm from the mid width of the wall. The specific gravity of masonary material is 1.8, find the depth of water.

SOME INTERESTING PROBLEMS

3.77. The pressure at the centre of pipe of diameter 3 m is 3 bar. The pipe contains oil of specific gravity of 0.85 and closed by gate value. Find the force exerted by the oil on the gate and position of centre of pressure.

3.78. The profile of the upstream face of the sea wall in contact with water is parabolic following the equation $2y = x^2$ where y is the height above the base and x is the horizontal distance of the face from the vertical reference line. The water level is 4.5 m above the base. Determine the total force and its direction of action and the position where the line of action of this force intersects the free water surface.

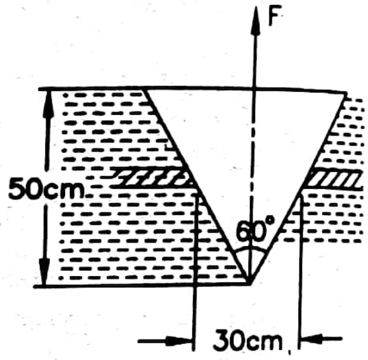


Fig-Ex. 3.78.

Take specific gravity of sea water = 1.025 (Ans. 136.3 kN, 48.4° with vertical and 5.25 m)

3.79. For a irrigation tank sluice, a conical plug of 100 N weight is used. Find the force required to just lift the plug when it is completely submerged in water as shown in Fig-Ex. 3.80.

3.80. A cone whose lowest generator is horizontal and the vertical angle is 2θ is filled with a liquid. Prove that the resultant force on the curved surface is $\sqrt{1+15\sin\theta}$ times the weight of liquid.

OBJECTIVE TYPE QUESTIONS

1. Total pressure per meter length of vertical wall is

   (a) $\frac{wh^2}{2}$ (b) $\frac{wh}{2}$ (c) $\frac{wh^3}{3}$ (d) None of the above.

   where h is the height of free surface of water from the base of the wall.

2. Depth of the centre of pressure from the free surface of water on a vertical wall is

   (a) $\frac{2}{3}h$ (b) $\frac{h}{3}$ (c) $\frac{h}{2}$ (d) None of the above.

3. The intensity of pressure p in a liquid is related to its specific weight w of the liquid and vertical height h of the point from free surface of liquid by the equation

   (a) $p = wh$ (b) $h = pw$ (c) $p = wh^2$ (d) $h = wp^2$.

4. The point of application of the total pressure force on the plane surface is

   (a) Centroid of the surface (b) Centre of pressure
   (c) Either of the above (d) None of the above.

5. If A is surface area immersed in liquid whose specific weight is w and h_g is the height of centre of gravity of the immersed surface from free surface of water, then the total pressure force F is given by

   (a) $F = wA^2h_g$ (b) $F = w^2Ah_g$ (c) $F = wAh_g^2$ (d) $F = wAh_g$.

6. The centre of pressure h_c of a immersed inclined surface is given

(a) $h_c = h_g + \frac{I_{gg}}{h_g A}\sin\theta$ (b) $h_c = h_g + \frac{I_{gg}}{h_g A}\sin^2\theta$ (c) $h_c = h_g + \frac{I_{gg}^2}{h_g A}\sin\theta$ (d) $h_c = h_g + \frac{I_{gg}}{h_g A^2}\sin\theta$

7. Resultant pressure force on a sluice gate is given by

(a) $F = F_1 - F_2$ (b) $F = F_1 + F_2$ (c) $F = \sqrt{F_1^2 + F_2^2}$ (d) $F = \sqrt{F_1^2 - F_2^2}$.

8. A stationary liquid is so stratified that its density increases linearly with depth having a value of ρ_0 at the free surface. The pressure (p) at a depth h from free surface, is given by

(a) $p = \rho_0 g h$ (b) $p = \rho_0 g h^2$ (c) $p = \rho_0 g \frac{h^3}{3}$ (d) $p = \rho_0 g \frac{h^2}{2}$.

9. For an inclined plane submerged in a liquid, the centre of pressure will be
   (a) Above the top edge of area
   (b) In the same horizontal plane as the centre of gravity
   (c) Below the centre of gravity (d) None of the above.
10. A curved surface is submerged in a stationary liquid. The horizontal component of the pressure force on it is equal to
   (a) The pressure force on a horizontal projection of the surface
   (b) The pressure force on vertical projection of the surface
   (c) The product of the surface area and pressure at the centre of gravity
   (d) Weight of liquid contained between curved surface and liquid surface.
11. A hollow hemi-spherical object of diameter D was immersed in water with its plane surface coinciding with the free surface. The vertical component of the force (F_v) on the curved surface is given by

(a) $F_v = \frac{3}{8} w\pi D^3$ (b) $F_v = \frac{1}{12} w\pi D^3$ (c) $F_v = \frac{1}{24} w\pi D^3$ (d) Zero.

12. A rectangular plate 75 cm × 240 cm is immersed in a liquid of weight density 0.85 with its 75 cm side horizontal and just at the water surface. If the plane of the plate makes an angle of 60° with the horizontal, the pressure force (F) on one side of the plate is given by
   (a) F = 15.6 kN (b) F = 24 kN (c) F = 18 kN (d) F = 7.8 kN.
13. A circular annular plate bounded by two concentric circles of diameter 120 cm and 80 cm is immersed in water with its plane making an angle 45° with horizontal. If the centre of the circles is 1.625 m below the free surface, the total pressure force (F) acting on one side is given by
   (a) F = 7.07 kN (b) F = 10.0 kN (c) F = 14.14 kN (d) F = 18.0 kN.
14. A cylindrical tank 2 m in diameter is laid with its axis horizontal and completely filled with water when both ends are closed. The force on one end of the plate is given by
   (a) F = 123 kN (b) F = 61.5 kN (c) F = 30.76 kN (d) F = 19.6 kN.
15. Which of the following is a possibility of dam failure
   (a) Failure due to sliding (b) Failure due to tension or compression
   (c) Failure due to overturning (d) All of the above.

ANSWERS

1. (a),	2. (b),	3. (a),	4. (b),	5. (d),
6. (b),	7. (a),	8. (d),	9. (c),	10. (b),
11. (b),	12. (a),	13. (b),	14. (c),	15. (d).

OBJECTIVE TYPE QUESTIONS

Choose the Correct Answers

1. When a body is immersed in liquid partly or completely, the buoyant force is equal to
(*a*) Weight of the body (*b*) Weight of volume of liquid equal to volume of body
(*c*) Weight of liquid displaced by the body (*d*) None of the above.
2. The point of application of the force of buoyancy on the body is known as
(*a*) Centre of gravity (*b*) Centre of buoyancy (*c*) Meta-centre (*d*) None of the above.
3. A floating body is in stable condition when
(*a*) MC is below C.G. (*b*) MC is above C.G. (*c*) MC height is zero (*d*) C-G is below C.B.
where MC is meta-centre, C.G. is centre of gravity and C.B. is centre of buoyancy.
4. The C.B. of a submerged body
(*a*) Concides with C.G. of the body (*b*) Is always below C.G.
(*c*) Concides with the centroid of the displaced volume of liquid
(*d*) C.B. is always above the centroid of the displaced volume of liquid.
5. A metal block is thrown in a sea. As it sinks deeper in water, the buoyant force acting on it
(*a*) remains constant (*b*) increases (*c*) decreases (*d*) first decreases and then increases.
6. When the ship enters into sea from a river, then it
(*a*) sinks little (*b*) rises little (*c*) remains at the same level
(*d*) rise or fall depends upon the density of the ship material.
7. A floating body displaces
(*a*) A volume of liquid equal to its own volume (*b*) A weight of liquid equal to its own weight
(*c*) A volume of liquid equal to its own submerged weight
(*d*) The weight of liquid which depends upon the capacity of the container.
8. A weight of an object is reduced from 100 N to 75 N when it deeped in water. The specific gravity of the object is
(*a*) 1.25 (*b*) 1.5 (*c*) 4 (*d*) 5
9. The volume of the iceburg floating in water is 12% outside the sea water whose specific gravity is 1.025. The specific gravity of the iceburg is
(*a*) 0.902 (*b*) 0.875 (*c*) 1.15 (*d*) 1.02.
10. A object weighs 50 N in water and 80 N in oil whose specific gravity is 0.8. Its volume in liters is
(*a*) 40 (*b*) 35.5 (*c*) 15.3 (*d*) 13.5.
11. For the stable equilibrium of the floating body the required condition is
(*a*) $GM = \frac{I}{V} \pm BG$ (*b*) $GM = \frac{I}{V} \times BG$ (*c*) $GM = \frac{I}{V} \times \frac{1}{BG}$ (*d*) $GM = BG - \frac{I}{V}$.
12. One cube of 1 m side (sp. gr. of material = 0.6) and another cube of 1 m side (sp. gr. of material = 1.15) are tied-up by a thread and then placed in water. Under equilibrium condition, the lighter cube will float above the water surface to a height of
(*a*) 10 cm (*b*) 15 cm (*c*) 20 cm (*d*) 25 cm.
13. The buoyant force acts through
(*a*) The C.G. of the body (*b*) C.G. of displaced liquid (*c*) The lowest point of the body
(*d*) Centroid of the volume of the body above the liquid.
14. A wooden cylinder floats in water, axis being parallel to water surface. The cylinder will be in
(*a*) Stable equilibrium (*b*) Unstable equilibrium
(*c*) Neutral equilibrium (*d*) None of the above.
15. A wooden platform 2 m × 2 m and 1 m height having sp. gr. = 0.5 floats in water. When a load of 9.81 kN is kept on the platform centrally, it will be submerged to a depth of
(*a*) 0.3 m (*b*) 0.75 m (*c*) 0.375 m (*d*) 0.5 m.

ANSWERS

1. (*c*)	**2.** (*b*)	**3.** (*b*)	**4.** (*c*)	**5.** (*a*)
6. (*b*)	**7.** (*b*)	**8.** (*c*)	**9.** (*a*)	**10.** (*c*)
11. (*a*)	**12.** (*d*)	**13.** (*b*)	**14.** (*c*)	**15.** (*b*).

114.6 RPM ; find the pressure at the centre of bottom and near the wall at the bottom (*b*) Find the rotational speed required when the depth of water at centre of bottom is zero.

(**Ans.** p_{centre} = 124 kN/m². $p_{at\ wall}$ = 142 kN/m² N = 169 RPM)

5.22 A conical vessel with included angle of 60° and 1.5 m high contains water whose volume is 50% of the vessel volume. Find the speed of rotation about its vertical axis so the water will just begin to spill. (**Ans.** 27 RPM)

5.23 A toy rocket of the shape of cone with height 1 m with its apex facing down is full of liquid. If the rocket moves vertically downward with constant acceleration of 8 m/s², find the pressure at the apex. The specific gravity of the liquid = 0.9. (**Ans.** 0.163 N/m²)

5.24 A conical vessel with apex down having an half angle θ is completely filled with water and rotated at 60 RPM. Then only 0.0142 m³ of water remained in it. Find the angle θ.
(**Ans.** θ = 36.13°)

OBJECTIVE TYPE QUESTIONS

1. An open tank containing liquid is given an acceleration in the upward direction, it causes :
(*a*) a decrease in hydrostatic pressure
(*b*) an increase in hydrostatic pressure
(*c*) no change in hydrostatic pressure
(*d*) none of the above.

2. When a vessel containing liquid is rotated with constant angular velocity about a vertical axis, the pressure :
(*a*) increases linearly along the radius
(*b*) increases parabolically along the radius
(*c*) decreases parabolically along the radius
(*d*) decreases linearly along the radius.

3. A right circular cylinder, open at top, is filled fully with water and then rotated about the vertical axis such that half the liquid spilled out. The pressure at the centre of the bottom is :
(*a*) zero
(*b*) unchanged
(*c*) half the value when the cylinder was full
(*d*) none of the above.

4. An oil tank is partially filled with oil and then moved with uniform linear acceleration. The free surface of the oil :
(*a*) remains horizontal
(*b*) is inclined with smaller depth at the rear
(*c*) is inclined with larger depth at the rear
(*d*) none of the above.

5. A circular cylinder partly filled with water is rotated about its vertical axis without spilling the water. The liquid surface rise at the cylinder wall above the original water level is :
(*a*) $\frac{\omega^2 R^2}{2g}$
(*b*) $\frac{\omega^2 R^2}{g}$
(*c*) $\frac{\omega^2 R^2}{4g}$
(*d*) $\frac{\omega^2 R^2}{8g}$

6. An open circular cylinder completely filled with oil is rotated about its vertical axis such that half the liquid is spilled out. Then the pressure at the centre of the cylinder is :
(*a*) half the pressure when the cylinder was full
(*b*) equal to atmospheric pressure
(*c*) the same as before rotation
(*d*) none of the above.

7. An open tank containing water upto 1 m depth is brought down in a lift with an acceleration of 0.1 g. The pressure at the bottom of the container is :
(*a*) w
(*b*) 1.1 w
(*c*) 0.9 w
(*d*) none of the above.

8. A water tank having a base of 4 m × 3 m and 2 m deep contains water upto 1 m and then accelerated horizontally parallel to 4 m side with 0.5 *g* Then
(*a*) the water surface slopes down at an angle of tan⁻¹ (0.5)
(*b*) the water surface sloped up at an angle of tan⁻¹ (0.5)

(c) 50% of the water spills out (d) the water surface remains horizontal.

9. An open cubical tank was filled with water and accelerated on a horizontal plane and it was found that $\frac{1}{3}$ of the water volume is spilled out. The acceleration was :

(a) $\frac{1}{3}g$ (b) g

(c) $\frac{1}{2}g$ (d) $\frac{2}{3}g$.

10. An open tank containing liquid is sliding down an inclined plane with uniform velocity. The free surface of the liquid :

(a) will be parallel to the plane of inclined plane

(b) will be inclined to the horizontal at an angle $\tan^{-1}\left(\frac{1}{g}\right)$

(c) will be horizontal.

(d) will be inclined to the horizontal whose angle of inclination depends upon the slope of inclined plane.

11. A circular cylinder containing liquid is rotated about its vertical axis at constant angular velocity. The pressure distribution :

(a) in any horizontal plane is uniform (b) in any vertical plane is uniform.

(c) on the bottom of the tank is uniform (d) in any vertical plane is hydrostatic.

12. A open box 2 m × 2 m contains liquid (sp. gr. = 0.8) upto the height of 2.5 m. It is accelerated vertically with an acceleration of 4.9 m/s^2, the pressure at the base of the tank is :

(a) 9.8 kPa (b) 19.6 kPa

(c) 29.4 kPa (d) 36.8 kPa.

13. A open circular tank of 1.2 m high is completely filled with a liquid and rotated about its vertical axis. The pressure at the centre of bottom was found equal to 0.3 m of liquid. The ratio of volume of liquid spilled out to the original volume is :

(a) $\frac{3}{4}$ (b) $\frac{1}{4}$

(c) $\frac{3}{8}$ (d) $\frac{1}{2}$

14. A open cylinder 20 cm in diameter contains liquid whose specific gravity is 0.8 upto the height of 20 cm. Then it is rotated with uniform angular velocity about the axis of the cylinder. If the centre of the bottom is just exposed to the atmosphere, the speed of rotation is :

(a) 94.6 RPM (b) 133.8 RPM

(c) 267.5 RPM (d) 535 RPM.

15. The pressure difference $(p_2 - p_1)$ between two points R_1 and R_2 in a liquid rotating about the centre is :

(a) $\frac{p\omega^2}{2}(R_2^2 - R_1^2)$ (b) $\frac{\omega^2}{2g}(R_2^2 - R_1^2)$

(c) $\frac{\omega^2}{2g}(R_1^2 - R_2^2)$ (d) $\frac{p\omega^2}{2}(R_1^2 - R_2^2)$

ANSWERS

1. (b)	2. (b)	3. (a)	4. (c)	5. (b)
6. (b)	7. (c)	8. (b)	9. (d)	10. (c)
11. (d)	12. (c)	13. (c)	14. (c)	15. (a)

OBJECTIVE TYPE QUESTIONS

Identify the Correct Answer

1. When a highly viscous fluid flows at a slow velocity, the flow becomes
   (a) Laminar (b) turbulent
   (c) uniform (d) steady.
2. If the mass flow rate of a liquid at every section of a pipe in its path of the flow is constant, then the flow is known as
   (a) uniform flow (b) steady flow
   (c) turbulent flow (d) none of the above.
3. If the velocity of flow at any section of the pipe in the path of the flow is constant, then the flow is called
   (a) steady flow (b) stream line flow
   (c) uniform flow (d) none of the above.
4. A flow of liquid at a constant rate in a uniformly tapered pipe is classified as
   (a) steady uniform flow (b) unsteady uniform flow
   (c) steady non-uniform flow (d) unsteady uniform flow.
5. Continuity equation for compressible fluid states that
   (a) discharge at any section is constant
   (b) discharge is different at different section
   (c) density is constant at all sections along the flow
   (d) none of the above.
6. The equation of stream line for two dimensional flow is given as
   (a) $\frac{dy}{u} = \frac{dx}{v}$ (b) $\frac{dx}{u} = \frac{dy}{v}$
   (c) $\frac{dx}{dt} = u$ and $\frac{dy}{dt} = v$ (d) $\frac{u}{dx} = \frac{dy}{v}$
7. If $\psi = 2xy$, the magnitude of velocity vector at a point $P(2, -2)$ is
   (a) $\sqrt{2}$ (b) $2\sqrt{2}$
   (c) $4\sqrt{2}$ (d) 4.
8. A continuity equation for two-dimensional compressible flow is given by
   (a) $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$ (b) $\frac{\partial}{\partial x}(\rho u) + \frac{\partial}{\partial y}(\rho v) = 0$
   (c) $u\frac{\partial u}{\partial y} + v\frac{\partial v}{\partial y} = 0$ (d) $u\frac{\partial \rho}{\partial x} + v\frac{\partial \rho}{\partial y} = 0$.
9. A continuity equation given below
   $$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$
   (a) is valid for steady flow whether the flow is compressible or incompressible
   (b) is not valid for incompressible, unsteady flow
   (c) is valid for incompressible flow whether the flow is steady or unsteady
   (d) is valid for ideal fluid flow only.
10. A flow has diverging straight stream lines. If the flow is steady, the flow
    (a) is uniform with local acceleration
    (b) has convective tangential acceleration
    (c) has convective normal acceleration
    (d) has both convective normal and tangential accelerations.

11. In a taper-duct, the area along the flow through the duct changes as given by

$A_x = 0.4 - 0.1\,x$, where x is in meters.

At a given instant, the discharge is 480 L/s and it was found that it increased at a rate of 120 L/s, the local acceleration (m/s^2) at $x = 0$ is

(a) 3.6 (b) $-$ 1.6

(c) 2.3 (d) 0.3.

12. In a two-dimensional unsteady—state flow, the acceleration component along X-direction is given by

(a) $u\dfrac{\partial u}{\partial x} + v\dfrac{\partial v}{\partial y} + \dfrac{\partial u}{\partial t}$ (b) $u\dfrac{\partial u}{\partial x} + v\dfrac{\partial u}{\partial y} + \dfrac{\partial u}{\partial t}$

(c) $u\dfrac{\partial u}{\partial x} + v\dfrac{\partial u}{\partial y}$ (d) $u\dfrac{\partial v}{\partial y} + v\dfrac{\partial u}{\partial x} + \dfrac{\partial u}{\partial t}$

13. In 3-dimensional flow, the component of rotation about X-axis is

(a) $\dfrac{1}{2}\left(\dfrac{\partial v}{\partial x} - \dfrac{\partial w}{\partial y}\right)$ (b) $\dfrac{1}{2}\left(\dfrac{\partial v}{\partial x} - \dfrac{\partial u}{\partial y}\right)$ (c) $\dfrac{1}{2}\left(\dfrac{\partial u}{\partial z} - \dfrac{\partial w}{\partial y}\right)$ (d) $\dfrac{1}{2}\left(\dfrac{\partial w}{\partial y} - \dfrac{\partial v}{\partial z}\right)$

14. A two dimensional flow in X-Y plane is irrotational if

(a) $\dfrac{\partial v}{\partial x} = \dfrac{\partial u}{\partial y}$ (b) $\dfrac{\partial u}{\partial x} = \dfrac{\partial v}{\partial y}$ (c) $\dfrac{\partial v}{\partial x} = \dfrac{\partial v}{\partial y}$ (d) $\dfrac{\partial u}{\partial x} = \dfrac{\partial u}{\partial y}$.

15. If ψ is a stream function for a given flow field, then the velocity components u and v are given by

(a) $u = -\dfrac{\partial \psi}{\partial y}$ and $v = -\dfrac{\partial \psi}{\partial x}$ (b) $u = \dfrac{\partial \psi}{\partial x}$ and $v = -\dfrac{\partial \psi}{\partial y}$

(c) $u = \dfrac{\partial \psi}{\partial y}$ and $v = -\dfrac{\partial \psi}{\partial x}$ (d) $u = \dfrac{\partial \psi}{\partial y}$ and $v = \dfrac{\partial \psi}{\partial x}$.

16. A two dimensional flow field is represented by $y = x^2 - y^2$, the velocity at point P (1, 1) is

(a) 2 (b) 4 (c) 8 (d) $2\sqrt{2}$.

17. If ϕ is a velocity potential function for a two dimensional fluid flow, then the velocity components are given by

(a) $u = \dfrac{\partial \phi}{\partial x}$ and $v = \dfrac{\partial \phi}{\partial y}$ (b) $u = -\dfrac{\partial \phi}{\partial x}$ and $v = \dfrac{\partial \phi}{\partial y}$

(c) $u = \dfrac{\partial \phi}{\partial y}$ and $v = \dfrac{\partial \phi}{\partial x}$ (d) $u = -\dfrac{\partial \phi}{\partial y}$ and $v = \dfrac{\partial \phi}{\partial x}$.

18. If a stream function ψ exists for a flow and satisfy the Laplace equation, then

(a) the flow is rotational

(b) the flow is irrotational and satisfies the continuity equation

(c) the flow is irrotational but need not satisfy the continuity equation

(d) the flow satisfies continuity equation but does not necessary satisfy the condition for irrotational flow.

19. If the stream function ψ exists, then it implies that

(a) the flow is irrotational (b) the flow is steady and incompressible

(c) the function ψ represents possible flow field

(d) none of the above.

20. A velocity potential function exists

(a) when the flow satisfies the continuity equation

(b) when the flow satisfies the condition of irrotational motion

(c) when the flow is rotational (d) none of the above.

21. A potential function exists for
(a) steady flow only
(b) for two dimensional irrotational flow only
(c) irrotational flow of fluid whether compressible or incompressible
(d) irrotational flow of incompressible fluids only.

22. A stream line is defined as
(a) $\phi = C$ (b) $\psi = C$ (c) $\frac{\partial \psi}{\partial x} = C$ (d) $\frac{\partial \phi}{\partial x} = C.$

23. In a steady flow, the velocity
(a) does not change from place to place
(b) at a given point does not change with time.
(c) may change its direction but the magnitude remains same
(d) none of the above.

24. The flow in a pipe when the valve is opened or closed gradually is an example of
(a) unsteady flow (b) steady flow
(c) rotational flow (d) compressible flow.

25. The type of flow in which the velocity at any given time does not change with respect to position is known as
(a) steady flow (b) rotational flow
(c) compressible flow (d) uniform flow.

26. The flow in a river during the period of heavy rainfall is
(a) steady, non-uniform and 3-dimensional
(b) steady uniform, two dimensional
(c) unsteady, non-uniform and 3-dimensional
(d) unsteady, uniform and 3-dimensional.

27. The continuity equation is mathematical representation of the principle of
(a) conservation of mass (b) conservation of momentum
(c) conservation of energy (d) all of the above.

28. An irrotational flow is one in which
(a) the stream lines of the flow are curved and parallel
(b) the fluid does not rotate as it moves forward
(c) the net rotation of fluid particles about their mass centres remains zero
(d) none of the above.

29. The concept of stream function which is based on the principle of continuity equation is applicable to
(a) irrotational flow only (b) two dimensional flow only
(c) three dimensional flow (d) uniform flow only.

30. If the velocity potential function ϕ satisfies the Laplace equation, it represents
(a) unsteady, compressible, rotational flow
(b) steady, incompressible, irrotational flow
(c) steady, compressible, irrotational flow
(d) unsteady, compressible rotational flow.

PATTERNS OF FLOW

31. The stream function ψ at any point (x, y) in a uniform flow parallel to X-axis is

(a) Ux, (b) Uy (c) $U\sqrt{x^2+y^2}$ (d) $U/\sqrt{x^2+y^2}$

32. A source in two-dimensional flow

(a) is a point from which fluid issues outward radially in all directions

(b) is a line from which fluid issues outward normally to the line

(c) has stream lines that are concentric circles (d) cannot exist.

33. A doublet is obtained by

(a) combining source and sink of equal strength

(b) combining source with uniform flow

(c) combining sink with uniform flow

(d) combining source and sink of equal strength Q which has a limiting value of $Q. ds$ when $ds \to 0.0$ where ds is the distance between source and sink.

34. The potential lines in case of doublet are

(a) circle tangential to X-axis (b) circles tangential to Y-axis

(c) lines parallel to X-axis (d) lines parallel to Y-axis.

35. Flow pattern over the half body is obtained by combining the flow patterns of

(a) source and sink (b) source and doublet

(c) uniform flow and doublet (d) source and uniform flow.

36. The distance of the nose of the half body from the source is

(a) $\frac{Q}{2\pi U}$ (b) $\frac{Q}{\pi U}$ (c) $\frac{2Q}{\pi U}$ (d) $\frac{Q}{4\pi U}$

37. The maximum width of the half body is

(a) $\frac{Q}{U}$ (b) $\frac{U}{Q}$ (c) $\frac{2Q}{U}$ (d) $\frac{Q}{4U}$

38. The pressure on the half body is the same as the static pressure of uniform stream approaching at a location θ whose value is

(a) 113° (b) 120° (c) 90° (d) 60°.

39. The stagnation points in case of uniform flow over the cylinder are at angles

(a) 0°, 90° (b) 90°, 180° (c) 0, 180° (d) 90°, 270°.

40. The velocity at the highest point on the cylinder due to uniform flow U is

(a) U (b) 0 (c) $\frac{U}{2}$ (d) $2U$

ANSWERS

1. (a)	2. (b)	3. (c)	4. (c)	5. (b)
6. (b)	7. (c)	8. (b)	9. (c)	10. (b)
11. (d)	12. (b)	13. (d)	14. (a)	15. (c)
16. (d)	17. (a)	18. (b)	19. (c)	20. (b)
21. (c)	22. (b)	23. (b)	24. (a)	25. (d)
26. (c)	27. (a)	28. (c)	29. (b)	30. (b)
31. (b)	32. (a)	33. (d)	34. (b)	35. (d)
36. (a)	37. (a)	38. (a)	39. (c)	40. (d)

7.39. A window in a vertical wall is 12 m above the ground level. A jet of water issued from a nozzle of 5 cm diameter is to strike the window. The nozzle is 1 m above the ground level. Find the greatest horizontal distance from the wall of the nozzle so that the water jet strikes the window bottom. The discharge through the nozzle is 40 L/s. **(Ans.** 29.4 m)

VORTEX-FLOWS

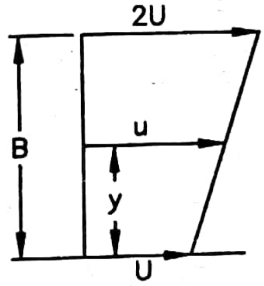
7.40. In a free cylindrical vortex of water, the tangential velocity at a radius of 10 cm from the axis is 10 m/s and the intensity of pressure is 200 kPa. Find the intensity of pressure at radius of 20 cm from the axis.

7.41. A cyclone flow may be considered as free vortex flow. The velocity of air in such flow is found 16 km/hr at 50 km from the centre of cyclone. What pressure gradient should be obtained at this point.

7.42. The tangential velocity at 10 cm from axis in a free cylindrical vortex is found as 3 m/s and pressure is 2.8 bar. Find the pressure at a radius of 20 cm.

7.43. A open cylindrical tank 1 m in diameter and 2 m high contains water upto 1.3 m. If the cylinder rotates at 10 rad/s about its axis, find the pressure at the bottom of the tank at a distance of 40 cm from the centre.

7.44. Find the momentum and energy correction factors for the velocity distribution shown in Fig.-Ex. 7.44 and *b* for two dimensional duct.



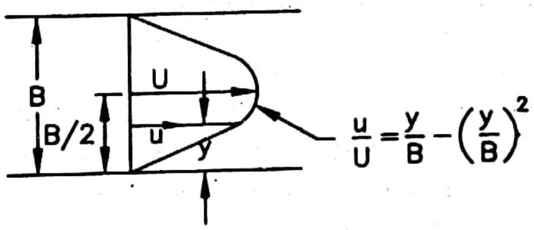


Fig.-Ex. 7.44.

7.45. A conical pipe has diameters 40 cm and 80 cm at its two ends. The smaller end is 2 m above the bigger end. For the flow of 300 L/s of water with, the pressure at lower end is 10 kPa. Assuming the head loss of 2 m and K.E. correction factors 1.1 and 1.5 at the smaller and larger ends respectively, find the pressure at the smaller end. **(Ans.** 7.14 kPa)

OBJECTIVE QUESTIONS

Identify the Correct Answer

1. Bernoulli's equation is applicable to
   (*a*) Steady flow (*b*) Unsteady flow
   (*c*) Both steady and unsteady flow (*d*) None of the above.
2. Bernoulli's equation is applicable to
   (*a*) Compressible flow (*b*) In compressible flow
   (*c*) Both compressible and incompressible flow (*d*) None of the above.
3. Bernoulli's equation for steady state, uniform flow, non-viscous and incompressible flow is represented by
   (*a*) $\frac{p}{\rho g}+\frac{V^2}{2g}+gZ=C$ (*b*) $\frac{p}{\rho g}+\frac{V^2}{2g}+Z=C$ (*c*) $\frac{p}{\rho}+\frac{V^2}{2g}+Z=C$ (*d*) $\frac{p}{\rho g}+\frac{V^2}{2}+Z=C$.
4. Each term of Bernoulli's equation represents
   (*a*) Energy (Nm/N) (*b*) Energy (kW/kg) (*c*) Energy (kg_f-m/kg) (*d*) Energy (Nm/kg).
5. In the Bernoulli's equation, it is assumed that the velocity at a section is
   (*a*) Uniform (*b*) Non-uniform
   (*c*) It decreases from the centre towards periphery (*d*) None of the above.

6. Bernoulli's equation takes into account
   (a) Friction loss (b) Loss due to change of direction
   (c) All types of losses (d) None of the above.
7. Bernoulli's equation is applicable between any two points
   (a) When flow is rotational and fluid is incompressible
   (b) Irrotational flow of any type of fluid
   (c) Steady rotational flow of incompressible fluid
   (d) Steady, irrotational flow of incompressible fluid.
8. Total head in a flow is the sum of
   (a) Piezometric head and datum head (b) Piezometric head and velocity head
   (c) Piezometric head and pressure head (d) Piezometric head, velocity head and datum head.
9. In a siphon, the summit is 4 m above the water level in the tank. If the head loss from the inlet of the siphon to the summit is 2 m and velocity head is 0.5 m, then the pressure at the summit is
   (a) – 63.6 kPa (b) – 9 m of H_2O (c) – 40.5 kPa (d) – 8.5 cm of Hg.
10. Bernoulli's equation is derived making assuming that
   (a) The flow is uniform and incompressible
   (b) The flow is uniform, non-viscous and incompressible
   (c) The flow is steady, uniform, non-viscous and incompressible (d) None of the above.
11. The venturi-meter is used to measure
   (a) Flow through a pipe (b) Flow through canal (c) Flow through river (d) None of the above.
12. In venturi-meter
   (a) Length of convergent part is > length of divergent part
   (b) Length of divergent part is > length of convergent part
   (c) Length of convergent part = Length of divergent part.
   (d) These is no restriction regarding lengths of convergent and divergent parts.
13. The function of orifice meter is to measure
   (a) The velocity of flowing fluid through the pipe line
   (b) The mass flow through the pipe line
   (c) The discharge through the pipe line (d) None of the above.
14. A venturimeter is preferable to orifice meter, because
   (a) It is cheaper (b) It is more convenient (c) Energy loss is less (d) It is easy to assemble.
15. A pitot tube is used to measure
   (a) Viscosity of the fluid (b) Mass flow rate (c) Velocity of the fluid (d) None of the above.
16. The coefficient of discharge (C_d) for orifice meter is
   (a) Greater than venturi-meter (b) Less than venturi-meter
   (c) Equal to venturi-meter (d) May be greater or less than, venturi-meter.
17. The forces considered in the derivation of Euler's equation of motion are
   (a) Pressure, inertia and gravity (b) Pressure, shear and gravity
   (c) Pressure, gravity and compressibility (d) None of the above.
18. The range of coefficient of discharge for venturi-meter is
   (a) 0.64 to 0.68 (b) 0.7 to 0.8 (c) 0.8 to 0.9 (d) 0.96 to 0.98.
19. The coefficient of discharge (C_d) in terms of Cu (coefficient of velocity and C_c (coefficient of contraction) is given by
   (a) $C_d = \frac{C_v}{C_c}$ (b) $C_d = \frac{C_c}{C_v}$ (c) $C_d = C_c \cdot C_v$ (d) None of the above.
20. The forces on pipe bend can be obtained by using
   (a) Momentum and continuity equations (b) Momentum and Energy equations
   (c) Energy and continuity equation (d) Momentum equation alone.

21. The general impulse-momentum principle can be applied if
(a) The flow is compressible or incompressible (b) The fluid is real or ideal
(c) The energy losses are unknown (d) All the above.

22. The equation $\Sigma F_x = \rho Q (V_{2x} - V_{1x})$ requires the following assumption
(a) Flow is steady (b) Velocity at both sections is uniform
(c) Flow is frictionless (d) All of the above.

23. The path of a free jet of liquid is
(a) Straight line (b) Parabola (c) Hyperbola (d) Sine curve.

24. The tangential velocity in a free vortex.
(a) Varies directly to radius (b) Varies inversely to the radius
(c) Varies directly to R^2 (d) None of the above is correct.

25. A jet of liquid is issued through a nozzle inclined to horizontal by 60° upward. The starting velocity of jet is 18 m/s. The maximum vertical distance achieved by the jet above the nozzle is
(a) 12.4 m (b) 16.5 m (c) 14.3 m (d) 8.2 m.

26. A nozzle of 5 cm diameter emits liquid at a velocity of 20 m/s making an angle 30° to the horizontal. At the point of maximum height; the jet is assumed to be unbroken, then the diameter of the jet is
(a) 5 cm (b) 5.4 cm (c) 2.6 cm (d) 4.7 cm.

27. A water jet with a velocity of 20 m/s is directed along a direction making an angle of 45° to the horizontal the maximum height is achieved by the jet at a horizontal distance x from the nozzle, the value of x is
(a) 10.2 m (b) 14.4 m (c) 40.8 m (d) 20.4 m.

28. The pressure variation along the radial direction for vortex flow along a horizontal plane is given by
(a) $\frac{\partial p}{\partial r} = -\rho \frac{V^2}{r}$ (b) $\frac{\partial p}{\partial r} = \rho \frac{V}{r^2}$ (c) $\frac{\partial p}{\partial r} = \rho \frac{V^2}{r}$ (d) None of the above.

29. For a forced vortex-flow, the height of paraboloid is equal to
(a) $\frac{p}{w} + \frac{V^2}{2g}$ (b) $\frac{V^2}{2g}$ (c) $\frac{V^2}{r^2} \cdot \frac{1}{2g}$ (d) $\frac{wr^2}{2g}$.

30. The constant velocity distribution over a cross-section
(a) K.E. correction factor is unity (b) Momentum correction factor is unity
(c) Both (a) and (b) are unity (d) Both (a) and (b) are not unity.

31. The velocity in a cross-section is non-uniform. The K.E. of fluid per Newton weight is given by
(a) $\frac{V^2}{2g}$ (b) $\alpha \frac{V^2}{2g}$ (c) $\beta \frac{V^2}{2g}$ (d) $\frac{p}{w}$.

32. The kinetic energy correction factor α is given by
(a) $\frac{1}{A^3V^3} \int v^3 \, .dA$ (b) $\frac{1}{A} \int v^3 \, .dA$ (c) $\frac{1}{AV^3} \int v^3 \, .dA$ (d) $\frac{1}{AV^3} \int v \, .dA$.

33. For the flow in a pipe correct state regarding the kinetic energy correction factor is
(a) $\alpha_{laminar} < \alpha_{turbulent}$ (b) $\alpha_{laminar} = \alpha_{turbulent}$ (c) $\alpha_{laminar} = 1.33$ (d) $\alpha_{turbulent} = 2$.

34. A pipe 15 cm in diameter carries oil (sp. gr. = 0.75) at a rate of 70 L/s. At a section 0.12 m above datum the pressure is equivalent to 2 cm of mercury vacuum. If the kinetic energy correction factor for that section is 1.1 the total head at that section in meters of oil is
(a) 0.68 (b) 0.75 (c) 0.56 (d) 0.64.

ANSWERS

1. (a)	2. (b)	3. (b)	4. (a)	5. (a)	6. (d)	7. (d)
8. (b)	9. (a)	10. (c)	11. (a)	12. (b)	13. (c)	14. (c)
15. (d)	16. (b)	17. (a)	18. (d)	19. (c)	20. (a)	21. (a)
22. (d)	23. (a)	24. (b)	25. (a)	26. (b)	27. (d)	28. (c)
29. (b)	30. (c)	31. (b)	32. (c)	33. (d)	34. (d).	

8.46. In a rotary viscometer, the radii of cylinders are 50 mm and 50.5 mm. The torque measured is 0.45 Nm when the outer cylinder is rotated with 30 rad/s when the gap is filled with the oil is 5 cm and the torque recorded is 0.81 Nm when depth was 10 cm with the same speed. Find the viscosity of the oil. (**Ans.** 1.52 Poise)

8.47. The following data is obtained from a capillary tube viscometer.

Vol. collected = 50 cm^3, time taken = 5 minutes

Length of tube and diameter = 30 cm and 2 mm. If the head loss is 1.4 cm, find the viscosity.

8.48. Determine diameter of wooden ball (sp. gr. = 0.7) which can rise in oil (sp. gr. = 0.8 and $\mu = 0.02$ poise) with a uniform velocity of 1 m/s.

8.49. Determine the velocity of fall of drain drop of 0.003 mm diameter (ρ = 1000 kg/m^3) and $\nu = 0.15 \times 10^{-4}$ m^2/s.

8.50. Determine the velocity of fall through air (ρ = 1.2 kg/m^3, $\mu = 18.6 \times 10^{-6}$ Ns/m^2) of a mist drop of diameter of 0.005 mm.

OBJECTIVE TYPE QUESTIONS

1. Newton's Law of viscosity states the relation between

(*a*) simple stress of strain, (*b*) shear stress and shear strain,
(*c*) shear stress and velocity, (*d*) shear stress and pressure.

2. Poise is a unit of

(*a*) absolute viscosity of fluid, (*b*) kinematic velocity of fluid,
(*c*) specific weight of fluid, (*d*) density of fluid.

3. In Newtonian fluid

(*a*) shear stress is inversely proportional to rate of shear strain,
(*b*) shear stress is directly proportional to rate of shear strain,
(*c*) there is no relation between shear stress and shear strain,
(*d*) none of the above.

4. The velocity of fluid at which laminar flow changes to turbulent flow is known as

(*a*) linear velocity, (*b*) mean velocity, (*c*) maximum velocity, (*d*) critical velocity.

5. The Reynold number of the flow is given by

(*a*) $\text{Re} = \frac{\rho d V}{\mu}$, (*b*) $\text{Re} = \frac{\mu d V}{\rho}$, (*c*) $\text{Re} = \frac{\rho V}{\mu d}$, (*d*) $\text{Re} = \frac{\rho d}{\mu V}$.

6. If V_a is the average velocity at any section in a flow through pipe and U is the maximum velocity at that section, then the relation between them is given by

(*a*) $V_a = \frac{2}{3} U$, (*b*) $V_a = \frac{U}{3}$, (*c*) $V_a = \frac{U}{2}$, (*d*) $V_a = \sqrt{3}\, U$.

7. The velocity distribution in laminar flow through a pipe follows the law

(*a*) parabolic law, (*b*) logarithmic law, (*c*) linear law, (*d*) exponentional law.

8. The coefficient of friction for laminar flow through the pipe is given by

(*a*) $f = \frac{64}{\text{Re}}$, (*b*) $f = \frac{\text{Re}}{64}$, (*c*) $f = \frac{0.98}{\sqrt{\text{Re}}}$, (*d*) $f = \frac{\sqrt{\text{Re}}}{0.98}$.

9. The relation between the pressure gradient along the flow direction and shear gradient to the normal of flow dirction is given by

(*a*) $\frac{dp}{dx} = \mu \frac{d\tau}{dy}$, (*b*) $\frac{dp}{dx} = \frac{1}{\mu} \frac{d\tau}{dy}$, (*c*) $\frac{-dp}{dx} = \frac{d\tau}{dy}$, (*d*) $\frac{dp}{dx} = \mu \frac{d\tau}{dx}$.

10. The shear stress in fluid flowing between two fixed parallel plates with small gap

(*a*) is maximum at the centre of gap, (*b*) is constant over the section,
(*c*) is maximum at the plates and zero at the centre,
(*d*) none of the above.

11. The velocity distribution for laminar flow between two fixed parallel plates
(a) is constant at the cross-section,
(b) is max, at the centre, zero at the plates and varies linearly between the centre and plate,
(c) varies parabolically across the section,
(d) is zero at the plate, zero at the contre and varies parabolically in between.

12. The maximum velocity in a pipe when flow is laminar occurs at
(a) top of the pipe, (b) centre of the pipe,
(c) bottom of the pipe, (d) somewhere at the section except at the centre.

13. The shear stress in a flowing fluid through a pipe
(a) is constant over the section,
(b) is zero at the wall and increases linearly to the centre,
(c) is zero at the centre and varies linearly with the radius,
(d) varies parabolically across the section.

14. For laminar flow through two fixed parallel plates, the pressure drop
(a) varies linearly with average velocity, (b) varies inversely with average velocity,
(c) varies linearly as V_a^2, (d) varies inversely as V_a^2.

15. The pressure gradient $\frac{dp}{dx}$ in case of laminar flow between two fixed horizontal parallel plates is
(a) zero, (b) positive, (c) negative, (d) can be zero, positive or negative.

16. In laminar flow through a pipe, the discharge varies
(a) linearly as the viscosity, (b) as the square of radius,
(c) inversely as the viscosity, (d) inversely as the pressure drop.

17. The exact solution of viscous flow problem can be obtained from
(a) continuity equation, (b) Bernoullis equation,
(c) Euler's equation, (d) Navier Stoke equation.

18. An oil having ν = 0.25 stokes flows through a pipe of diameter 10 cm. The flow is critical at a velocity of
(a) 5 m/s, (b) 6.5 m/s, (c) 0.5 m/s, (d) 5.5 m/s.

19. An oil of μ = 1.5 Pas and sp. gr. = 0.9 flows through a pipe of 5 cm diameter with an average velocity of 1.2 m/s. The shear stress at wall (N/m^2) is
(a) 360, (b) 180, (c) 144, (d) 288.

20. A circular pipe carrying oil at Reynold number 100. If the discharged is tripled, the power input will be
(a) 3 times of original, (b) 9 times of original, (c) $\frac{d}{3}$ of original, (d) increased by 100%.

21. If the discharge is same through the given length of pipe, then power consumed in laminar friction varies as
(a) D^4, (b) D^2, (c) D^{-2}, (d) D^{-4}.

22. The liquid flowing through a pipe of 10 m long has head loss of 2 m. The Reynold number is 100. If the flow rate is doubled, the head loss will be
(a) 0.5 m, (b) 4 m, (c) 8 m, (d) 2 m.

23 The pressure drop in 8 cm diameter and 15 m length of pipe is 75 kN/m^2. The shear stress at the pipe in kN/m^2 will be
(a) 0.2, (b) 2, (c) 4, (d) 6.

24. The minimum value of friction factor f in a laminar flow through a circular pipe is
(a) 0.025, (b) 0.032, (c) 0.05, (d) 0.064.

25. A 20 cm diameter pipe carries an oil of density 900 kg/m^3. If the shear stress at the pipe wall is 0.5 N/m^2, the head loss in 100 m length of pipe is

(*a*) 11.35 m, (*b*) 5.85 m, (*c*) 8.6 m, (*d*) 6.8 m.

26. The friction factor in a laminar pipe flow is found as 0.04. The Reynold number will be

(*a*) 2000, (*b*) 1500, (*c*) 1000, (*d*) 1600.

27. In a laminar flow through a pipe of diameter *d*, the average velocity is indicated as local velocity (measured from the axis of pipe) at a radial distance of

(*a*) 0.354 d, (*b*) 0.543 d, (*c*) 0.534 d, (*d*) 0.453 d.

28. The centre line velocity of a pipe of 12 cm diameter in a laminar flow condition is 2 m/s. The velocity at 2 cm from the axis of the pipe is

(*a*) 0.22 m/s, (*b*) 0.33 m/s, (*c*) 1.66 m/s, (*d*) 1.78 m/s.

29. The wall shear stress in a pipe of 8 cm diameter carrying a laminar flow is 28 N/m^2. The shear stress at 3 cm from the axis is

(*a*) 74 N/m^2, (*b*) 7 N/m^2, (*c*) 21 N/m^2, (*d*) 12.5 N/m^2.

30. In a laminar flow between two fixed parallel plates with a distance of 6 mm, the centre line velocity is 1.8 m/s. The velocity at 1 mm from the plate surface is

(*a*) 0.15 m/s, (*b*) 1.5 m/s, (*c*) 1 m/s, (*d*) 0.75 m/s.

31. A fluid (ρ = 900 kg/m^3 and μ = 1.2 Ns/m^2 flows through two fixed parallel plates 3 cm apart. If the discharge is 216 m^3/m per meter width of the plate, the shear stress at the boundary in N/m^2 is

(*a*) 480, (*b*) 840, (*c*) 800, (*d*) 400.

32. In a laminar flow of liquid down an inclined plane, the surface velocity is 0.3 m/s. The average velocity of the flow in m/s is

(*a*) 0.2, (*b*) 0.225, (*c*) 0.15, (*d*) 0.1.

ANSWERS

1. (*b*)	**2.** (*a*)	**3.** (*b*)	**4.** (*d*)	**5.** (*a*)
6. (*c*)	**7.** (*a*)	**8.** (*a*)	**9.** (*c*)	**10.** (*c*)
11. (*c*)	**12.** (*b*)	**13.** (*c*)	**14.** –	**15.** (*c*)
16. (*c*)	**17.** (*d*)	**18.** (*c*)	**19.** (*d*)	**20.** (*b*)
21. (*d*)	**22.** (*b*)	**23.** (*a*)	**24.** (*b*)	**25.** (*a*)
26. (*d*)	**27.** (*a*)	**28.** (*d*)	**29.** (*c*)	**30.** (*c*)
31. (*a*)	**32.** (*a*).			

9.38. A 30 cm diameter pipe carries water at a mean velocity of 7.5 m/s. At the beginning, there is no roughness to the pipe surface but it is found that roughness grows at the rate of 0.075 mm/year. Find the number of years after which the surface roughness will affect the flow. Take $\nu = 0.01$ strokes (for water).

(**Hint :** $\epsilon = \delta_b$ to affect the flow)

(**Ans.** 2.7 years)

9.39. It is observed that a steel pipe of 60 cm diameter consumed 40% more power after 15 years of service when it has to deliver the water at the rate of 300 L/s. Determine the rate of increase in the roughness.

Take $\nu = 0.015$ strokes.

9.40. A CI-pipe ($\epsilon = 0.3$ mm) is to carry 200 L/s of oil ($\nu = 2.5 \times 10^{-6}$ m²/s). If the head loss is limited to 65 cm per 100 m length of pipe, find the required diameter of the pipe.

OBJECTIVE QUESTIONS

Identify the Correct Answer

1. In turbulent flow, a rough pipe has the same friction factor as a smooth pipe
(*a*) In zone of complete turbulence of rough pipe
(*b*) When $\epsilon << \delta_b$ (*c*) When Re is very high (*d*) None of the above.

2. In complete turbulence zone of rough pipe
(*a*) $h_f \propto V_a^2$ (*b*) $h_f \propto (V_a)^{1.75}$ (*c*) $h_f \propto \text{Re}$ (*d*) None of the above.

3. Aging of the pipe causes
(*a*) Decreases absolute roughness (*b*) Increases absolute roughness
(*c*) Increases discharge for the same head (*d*) Decreases discharge for the same head.

4. The intensity of turbulence refers to
(*a*) Correlation of u' and v'
(*b*) Root mean square value of turbulence velocity fluctuations
(*c*) The Reynold stresses (*d*) Average K.E. of turbulence per unit mass.

5. The turbulence shear stress in X-Y plane is given by
(*a*) $\rho \overline{u' v'}$ (*b*) $\rho u' v'$ (*c*) $\rho \overline{u'^2}$ (*d*) $\rho \overline{v'^2}$.

6. According to Prandtl mixing length theory, the shear stress is given by
(*a*) $\rho^2 l^2 \left(\frac{du}{dy}\right)^2$ (*b*) $\rho^2 l^2 \left(\frac{du}{dy}\right)$ (*c*) $\rho l^2 \left(\frac{du}{dy}\right)^2$ (*d*) $\rho l \left(\frac{du}{dy}\right)^2$.

7. If Δp is the loss of pressure between two sections L apart for a flow through a horizontal pipe of diameter D, then the wall shear stress is
(*a*) $\frac{\Delta p . D}{4L}$ (*b*) $\sqrt{\frac{\Delta p}{8}}$ (*c*) $\frac{\Delta p . L}{D}$ (*d*) $\frac{1}{2} \Delta p . L V_a^2$.

8. The shear stress in a turbulent flow through pipe is
(*a*) Maximum at the centre and decreases linearly towards wall
(*b*) Maximum at the wall and decreases linearly to zero at the centre
(*c*) Maximum at the centre and decreases logarithmically towards the wall
(*d*) Maximum at the wall and decreases logarithmically at the centre.

9. In turbulent flow, through a pipe, the term $\frac{\text{Re}\sqrt{f}}{\left(\frac{R}{\epsilon}\right)}$ is directly proportional to
(*a*) $\frac{\epsilon}{\delta_b}$ (*b*) $\frac{\delta_b}{R}$ (*c*) $\frac{R}{\delta_b}$ (*d*) $\frac{\delta_b}{\epsilon}$.

10. In a fully turbulent pipe flow, the velocity distribution in laminar sub layer, the velocity distribution is
(*a*) Parabolic (*b*) Logarithmic (*c*) Linear (*d*) Exponential.

11. In a turbulent flow through a pipe, the mean (V_a) and maximum (U) velocity are related as $\frac{U}{V_a}$ =

(a) 3.75 (b) $1.4\sqrt{f}+1$ (c) $1.3 \log_e \sqrt{f}$ (d) $1.3 \frac{1}{\log_e \sqrt{f}}$.

12. In a pipe flow, the shear velocity (u^*) is related to friction factor and mean velocity V_a as $\frac{u^*}{V_a}$ =

(a) $\sqrt{\frac{f}{2}}$ (b) $\sqrt{\frac{2}{f}}$ (c) $\sqrt{\frac{2g}{f}}$ (d) $\frac{1}{\sqrt{4f}}$.

13. In a pipe flow, the wall shear stress τ_0 is given by

(a) $2f\rho V_a^2$ (b) $\frac{2}{3}f\rho V_a^2$ (c) $f\rho V_a^2$ (d) $\frac{f\rho V_a^2}{2}$.

14. In a fully rough-turbulent flow; the friction factor f is a function of

(a) Re and $\frac{\epsilon}{D}$ (b) Re only (c) $\frac{\epsilon}{D}$ only (d) Independent of Re and $\frac{\epsilon}{D}$.

15. For hydrodynamically smooth pipe, the friction factor f

(a) is a constant (b) is a function of $\frac{\epsilon}{R}$ only

(c) is a function of $\frac{\epsilon}{R}$ and Re (d) is a function of Re only.

16. Two pipes of the same diameter carry the same fluid, one pipe is rough and other is smooth. If both the pipe have same friction factor carrying the same quantity of liquid, then

(a) the flow is rough-turbulent (b) $\epsilon << \delta_b$

(c) the flow is laminar (d) the flow is smooth turbulent.

17. In a turbulent flow through the pipe, the maximum velocity (U) and mean velocity (V_a) are related as $\frac{U-V}{u^*}$ =

(a) 3.75 for smooth pipe only

(b) 3.75 for rough pipe only

(c) 3.75 for both smooth and rough pipes

(d) 5.75 for both smooth and rough pipe.

18. In a turbulent flow through a pipe of radius R, the radial distance r where the local velocity (u) is equal to average velocity (V_a) is

(a) $r = 0$ (b) $r = 0.223\,R$ (c) $r = 0.5\,R$ (d) $r = 0.777\,R$.

19. A liquid flows through a 30 cm diameter pipe at Re = 10^6. If $f = 0.006$, the thickness of laminar sub layer δ_b in mm is

(a) 0.025 (b) 0.0025 (c) 0.062 (d) 0.0062.

20. In a turbulent flow through a pipe, the mean velocity is 2 m/s and friction factor $f = 0.005$. The maximum velocity U in m/s is

(a) 2.75 (b) 3.75 (c) 2.4 (d) 4.2.

ANSWERS

1. (b),	2. (a),	3. (b),	4. (b),	5. (a),
6. (c),	7. (a),	8. (b),	9. (a),	10. (c),
11. (a),	12. (a),	13. (d),	14. (c),	15. (d),
16. (b),	17. (c),	18. (d),	19. (c),	20. (c).

10.25. A thin plate of 1 m × 2 m moved through a water parallel to 2 m side with a velocity of 2 m/s. Determine the drag-force on both sides of the plate assuming the boundary layer is turbulent from the leading edge:

Take $$C_{fx} = \frac{0.06}{(Re_x)^{\frac{1}{5}}} = \frac{\tau_o}{\frac{1}{2}\rho U^2}$$

where τ_o $(\tau_x|_{y=0})$ is local shear stress.

OBJECTIVE QUESTIONS

Select the Correct Answers

1. Within the boundary layer, the pressure
   (a) remains constant and has the same value as that at the edge of the boundary
   (b) is atmospheric
   (c) varies linearly with the thickness of the boundary layer
   (d) is same as the approaching flow.
2. In a fluid stream of small viscosity,
   (a) The viscosity has no appreciable effect on the drag-force around the body placed in it.
   (b) There is a small region surrounding the body in which the effect of viscosity is predominant.
   (c) The flow pattern around the body is not much affected.
   (d) None of the above.
3. The shear stress at the boundary on flat surface $(\tau_0 = \tau_x|_{y=0})$ is given by
   (a) $\left.\frac{dp}{dx}\right|_{y=0}$ (b) $\left.\frac{du}{dy}\right|_{y=0}$ (c) $\mu \left.\frac{du}{dy}\right|_{y=\delta}$ (d) $\mu \left.\frac{du}{dy}\right|_{y=0}$.
4. The velocity distribution in the laminar boundary layer has to satisfy a condition
   (a) $u = U$ at $y = 0$ (b) $u = U$ at $y = \frac{\delta}{2}$ (c) $u = 0$ at $y = 0$ (d) $u = 0$ at $y = \delta$.
5. The drag-coefficient C_D for a flow over a flat plate of $L \times W$ placed in a uniform flow of velocity U is
   (a) $\frac{F_D}{\rho UA}$ (b) $\frac{F_D}{\frac{1}{2}\rho U^2 A}$ (c) $\frac{\rho UL}{\mu}$ (d) $\frac{\rho U^2 L}{2F_D}$.
6. The velocity distribution $\frac{u}{U} = \left(\frac{y}{\delta}\right)^{\frac{1}{7}}$ is valid if the boundary layer is
   (a) laminar (b) turbulent and $Re > 10^7$
   (c) turbulent and for any value of Re (d) of any type.
7. The local thickness of laminar boundary layer varies as
   (a) $(x)^{\frac{4}{3}}$ (b) $(x)^{\frac{1}{2}}$ (c) $(x)^{-\frac{1}{2}}$ (d) $(x)^{\frac{1}{7}}$.
8. The local thickness of turbulent boundary layer varies as
   (a) $(x)^{\frac{4}{3}}$ (b) $(x)^{\frac{1}{2}}$ (c) $(x)^{-\frac{1}{2}}$ (d) $(x)^{\frac{1}{7}}$.
9. The momentum thickness of a laminar boundary layer is defined as
   (a) $\int_0^{\delta}\left(1-\frac{u}{U}\right)dy$ (b) $\int_0^{\delta}\frac{u}{U}\left(1-\frac{u}{U}\right)dy$ (c) $\int_0^{\infty}\left(1-\frac{u}{U}\right)dy$ (d) $\int_0^{\infty}\frac{u}{U}\left[\left(1-\frac{u}{U}\right)^2\right]dy$.

10. The analysis of laminar boundary layer by Blasius is based on
(*a*) exact analysis of boundary layer equations (*b*) parabolic velocity distribution
(*c*) logarithmic velocity distribution (*d*) $\frac{1}{7}$ power law of velocity distribution.

11. The average drag coefficient for turbulent boundary layer over a flat plate is based on when $Re = 10^7$
(*a*) parabolic velocity distribution in boundary layer
(*b*) logarithmic velocity distribution in boundary layer
(*c*) linear velocity distribution in boundary layer
(*d*) one-seventh power law of velocity distribution in boundary layer.

12. Separation is caused by
(*a*) reducing the pressure to vapour pressure (*b*) reducing pressure gradient (dp/dx) zero
(*c*) accelerating the flow (*d*) positive pressure gradient.

13. The separation of boundary layer takes place when
(*a*) $\left.\frac{du}{dy^2}\right|_{y=0} > 0$ (*b*) $\left.\frac{du}{dy}\right|_{y=0} = 0$ (*c*) $\left.\frac{d^2u}{dy^2}\right|_{y=0} > 0$ (*d*) $\left.\frac{du}{dy}\right|_{y=\delta} > 0$

14. The growth of boundary layer when the flow takes place over a smooth flat plate (δ/x)
(*a*) decreases with an increase in kinematic viscosity when boundary flow is laminar only
(*b*) decreases with an increase in free stream velocity if the boundary layer is laminar only
(*c*) increases with an increase in kinematic viscosity in both laminar and turbulent boundary layers
(*d*) increases with increase in free stream velocity.

15. The rate of growth of boundary layer thickness on a flat plate along the flow direction
(*a*) is faster in laminar boundary layer than in turbulent boundary layer
(*b*) is faster in turbulent boundary layer than in laminar boundary layer
(*c*) is same whether the flow in boundary layer is laminar or turbulent
(*d*) none of the above is true.

16. The velocity u in turbulent boundary layer varies as $(y)^{\frac{1}{7}}$, then the growth of boundary layer thickness (δ/x) varies as
(*a*) $\sqrt{Re_x}$ (*b*) $\frac{1}{\sqrt{Re_x}}$ (*c*) $(Re_x)^{\frac{1}{5}}$ (*d*) $(Re_x)^{-\frac{1}{5}}$.

17. In a turbulent boundary layer over a flat plate (where $10^7 < Re < 10^9$), the growth of boundary layer (δ/x) varies as
(*a*) $(Re_x)^{\frac{1}{2}}$ (*b*) $(Re_x)^{\frac{1}{5}}$ (*c*) $(Re_x)^{-\frac{1}{5}}$ (*d*) $(Re_x)^{-\frac{1}{6}}$

18. When the boundary layer over a flat plate is turbulent from leading edge and $Re_L = 10^8$, the average drag-coefficient is given by
(*a*) $\frac{1.32}{\sqrt{Re_L}}$ (*b*) $\frac{0.074}{(Re_L)^{\frac{1}{5}}}$ (*c*) $\frac{0.37}{[\log_{10}(Re_L)]^{2.58}}$ (*d*) $\frac{0.445}{[\log_{10}(Re_L)]^{2.58}}$.

19. The velocity distribution in laminar boundary layer is given by $\frac{u}{U} = \frac{y}{\delta}$. The displacement thickness is
(*a*) δ (*b*) $\frac{\delta}{4}$ (*c*) $\frac{\delta}{6}$ (*d*) $\frac{\delta}{2}$.

20. The velocity distribution in laminar boundary layer is given by $\frac{u}{U} = \frac{y}{\delta}$, then $\frac{\theta^*}{\delta}$ is given by

(a) $\frac{1}{6}$ (b) $\frac{1}{3}$ (c) $\frac{1}{2}$ (d) $\frac{5}{4}$.

21. If the velocity distribution in turbulent flow is given by

$$\frac{u}{U} = \left(\frac{y}{\delta}\right)^{\frac{1}{10}} \text{ then the } \frac{\delta^*}{\delta} \text{ is given by}$$

(a) 0.076 (b) 0.091 (c) 0.125 (d) 0.33.

22. In a laminar boundary layer over a flat plate, the ratio of τ_{x_1}/τ_{x_2} where τ_{x_1} and τ_{x_2} are shear stresses at sections x_1 and x_2 from the leading edge of the plate and $x_2 = 5x_1$, the ratio τ_{x_1}/τ_{x_2} is

(a) $\frac{1}{5}$ (b) 5 (c) $\sqrt{5}$ (d) $\frac{1}{\sqrt{5}}$.

23. The velocity distribution in a turbulent boundary layer is given by $\frac{u}{U} = \left(\frac{y}{\delta}\right)^{\frac{1}{7}}$. If the whole boundary layer is turbulent and τ_{x_1} and τ_{x_2} are the shear stresses at the sections x_1 and x_2 from the leading edge of the plate and $x_2 = 5x_1$, then the ratio τ_{x_1}/τ_x is given by

(a) 1.26 (b) 2.16 (c) 1.38 (d) 3.18.

24. The average drag coefficient for a laminar boundary layer over a flat plate is found to be 0.015. If the length of the plate is reduced to $\frac{1}{4}$ of its original keeping the flow condition same, the average drag coefficient will be

(a) 0.015 (b) 0.030 (c) 0.045 (d) 0.060.

25. On a flat plate of length L, the point A is at $x = \frac{L}{2}$ and the point B is at $x = L$, the shear stresses at A and B are τ_a and τ_b, then

(a) $\tau_a > \tau_b$ (b) $\tau_a = \tau_b$ (c) $\tau_a < \tau_b$ (d) $\tau_a = \tau_b$ if the boundary is turbulent only.

ANSWERS

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

OBJECTIVE TYPE QUESTIONS

1. The function of the orifice is :
   (a) to measure discharge through a pipeline (b) to measure discharge through a tank
   (c) to measure discharge through tank as well as pipe line
   (d) to measure the velocity.
2. Theoretical velocity of flow through an orifice is :
   (a) $C_d \sqrt{2gh}$ (b) $2\sqrt{gh}$ (c) $\sqrt{2gh}$ (d) $h\sqrt{2g}$
3. The actual velocity of flow through an orifice is measured at :
   (a) the orifice (b) the vena contacta (c) anywhere in the jet (d) none of the above.
4. The relation between C_d, C_v and C_c is given by :
   (a) $C_d = \frac{C_v}{C_c}$ (b) $C_d = C_v C_c$ (c) $C_d = C_v - C_c$ (d) $C_d = C_v + C_c$
5. With experimental determination, the C_v is given by :
   (a) $C_v = \frac{x}{\sqrt{4yh}}$ (b) $C_v = \sqrt{\frac{x^2}{gyh}}$ (c) $C_v = \sqrt{\frac{x^2}{4ghy}}$ (d) none of the above.
6. The loss of head through an orifice is given by :
   (a) $h(1 - C_v^2)$ (b) $C_v(1 - h^2)$ (c) $C_v^2(h - 1)$ (d) $h\left(1 - \frac{1}{C_v^2}\right)$
7. Discharge through a large-rectangular orifice is :
   (a) $\frac{2}{3} C_d b \sqrt{2g}\left[h_2^{1.5} - h_1^{1.5}\right]$ (b) $\frac{3}{2} C_d b \sqrt{2g}\left[h_2^{1.5} - h_1^{1.5}\right]$
   (c) $2 C_d b \sqrt{2g}\left[h_2^{1.5} - h_1^{1.5}\right]$ (d) $3 C_d b \sqrt{2g}\left[h_2^{1.5} - h_1^{1.5}\right]$.
   where $h_2 > h_1$
8. Discharge through a drowned large orifice is equal to:
   (a) $C_d b\, 2g \sqrt{(h_2 - h_1) h}$ (b) $C_d b \sqrt{2gh}\,(h_2 - h_1)$
   (c) $C_d b \sqrt{2g (h_2 - h_1)}\; h$ (d) none of the above.
9. The time for drop in height from h_1 to h_2 in a tank when discharge takes place through an orifice is given by :
   (a) $\frac{2A}{C_d a \sqrt{2g}}\left(h_1^{0.5} - h_2^{0.5}\right)$ (b) $2aA C_d \sqrt{2g}\left(h_1^{0.5} - h_2^{0.5}\right)$
   (c) $\frac{A}{2 C_d a \sqrt{2g}}\left(h_1^{0.5} - h_2^{0.5}\right)$ (d) none of the above.
10. A hemispherical bowl of radius R full of water is emptied through an orifice of area a and C_d located at the bottom is given by :
   (a) $\frac{4\pi}{K}\left[\frac{2}{15} R^{2.5}\right]$ (b) $\frac{2\pi}{K}\left[\frac{7}{15} R^{2.5}\right]$ (c) $\frac{2\pi}{K}\left[\frac{2}{15} R^{2.5}\right]$ (d) none of the above.
   where $K = C_d a \sqrt{2g}$
11. The time for flow from one vessel to another through an orifice when the level difference between them becomes zero is given by :
   (a) $\frac{2 A_1 A_2}{(A_1 + A_2) K}(H_1)^{0.5}$ (b) $\frac{2 A_1 A_2}{(A_1 + A_2) K}(H_1)^{1.5}$ (c) $\frac{2 A_1 A_2}{(A_1 + A_2) K}(H_1)^{2.5}$ (d) none of the above.
   where H_1 is the difference in levels between two tanks at the beginning and $K = C_d a \sqrt{2g}$.

12. A fluid jet discharging form a 5 cm diameter orifice has a diameter of 4 cm at its vena contracta. The coefficient of contraction is :

(a) 0.8 (b) 1.25 (c) 0.64 (d) $\sqrt{0.8}$.

13. Which mouth piece has maximum coefficient of discharge :

(a) external mouth piece (b) internal mouth piece

(c) convergent-divergent mouth-piece (d) none of the above.

14. An orifice of 20 cm diameter discharging from a tank issues a jet of liquid of 15.75 cm diameter at the vena-contracta. The coefficient of contraction is :

(a) 0.55 (b) 0.62 (c) 0.79 (d) 0.825.

15. If a tank discharges water through an orifice under a variable head h, the water surface will be lowered at a constant velocity if the surface area varies as :

(a) $\sqrt{h}$ (b) $\frac{1}{\sqrt{h}}$ (c) $\frac{1}{h}$ (d) h.

16. The C_d of the orifice is always :

(a) greater than C_c (b) less than C_c (c) equal to C_v (d) equal to C_c.

17. The water level in a cylindrical tank with its axis vertical is lowered from 4 m to 2 m in 200 seconds through an orifice located at bottom. If the diameter of orifice is doubled, the time required for lowering the same level will be :

(a) 100 s (b) 25 s (c) 50 s (d) 75 sec.

18. In a prismatic tank of surface area A, water surface is lowered by discharging through a orifice at the bottom. If the head over the orifice is h at time t, the velocity of water surface in the tank is :

(a) $-\frac{dA}{dt}$ (b) $-\frac{dh}{dt}$ (c) $\sqrt{2gh}$ (d) none of the above.

19. In a submerged orifice, the discharge is proportional to :

(a) $\sqrt{h_1}$ (b) $\sqrt{h_2}$ (c) h_1^2 (d) $\sqrt{h_1 - h_2}$

where h_1 and h_2 are the upstream and downstream heads from the axis of the orifice.

20. A Borda's internal mouth piece of 10 cm diameter running free discharges 24 L/s under a head of 2 m. The coefficient of velocity C_v is :

(a) 0.5 (b) 0.95 (c) 0.62 (d) 0.976.

ANSWERS

1. (c)	2. (c)	3. (b)	4. (b)	5. (a)
6. (a)	7. (a)	8. (b)	9. (a)	10. (b)
11. (a)	12. (c)	13. (c)	14. (b)	15. (a)
16. (b)	17. (c)	18. (b)	19. (d)	20. (d)

12.39. Find the discharge over 30 m broad crested weir when the head is 120 cm. Take $C_d = 0.61$
(**Ans.** 41 m^3/s)

12.40. A tank with constant surface area of 2 m^2 was emptied by a rectangular 30 cm long weir. If the rate of lowering the head in the tank was 4.5 cm/s when the head was 30 cm, find out the discharge coefficient of weir.
(**Ans.** 0.62)

OBJECTIVE TYPE QUESTIONS

1. A weir is said to be broad-crested if

(a) $B > \frac{H}{2}$ (b) $B > \frac{2}{3}$ (c) $B > \frac{H}{n}$

(d) None of the above. Where B is the width of the broad-crested weir

2. In a weir the discharge is proportional to

(a) H, (b) $\sqrt{H}$, (c) H^2, (d) H^n.

3. In a weir, the pressure below the lower nappe is

(a) Atmospheric, (b) Below atmospheric,

(c) Above atmospheric, (d) Depends upon the head over the weir.

4. A rectangular weir of width b is divided into three sections by two piers. It's effective width is

(a) $b - 0.6\,H$, (b) $b - 0.3\,H$, (c) $0.6\,b$, (d) $0.3\,b$.

5. An error of 1% in head measurement over a triangular notch rerults in error in discharge of

(a) 1.5 %, (b) 2.5 %, (c) 5 %, (d) 1%.

6. Notch is used for measuring

(a) The rate of flow through pipes, (b) the rate of flow through a small channel,

(c) velocity through pipe, (d) velocity through a small channel.

7. The discharge through a rectangular notch is given by

(a) $Q = \frac{2}{3} C_d\, b\, (H)^{2.5}$, (b) $Q = \frac{2}{3} C_d\, b\, (H)^{1.5}$, (c) $Q = \frac{8}{15} Cd\, b\, (H)^{1.5}$, (d) $Q = \frac{8}{15} C_d\, b\, (H)^{2.5}$.

8. The discharge through a triangular notch is given by

(a) $Q = \frac{2}{3} C_d \tan\theta \sqrt{2gH}$, (b) $Q = \frac{2}{3} C_d \tan\theta \sqrt{2g}\ (H)^{1.5}$,

(c) $Q = \frac{5}{18} C_d \tan\theta \sqrt{2g}\ (H)^{2.5}$; (d) None of the above.

Where θ is half angle of triangular notch and H is the head over the notch.

9. The error in discharge due to error in the head measurement over a rectangular notch is given by

(a) $\frac{dQ}{Q} = \frac{5}{2}\frac{dh}{h}$, (b) $\frac{dQ}{Q} = \frac{3}{2}\frac{dh}{h}$, (c) $\frac{dQ}{Q} = \frac{7}{2}\frac{dh}{h}$, (d) $\frac{dQ}{Q} = \frac{1}{2}\frac{dh}{h}$.

10. The error in discharge due to error in the head measurement over a triangular notch is given by

(a) $\frac{dQ}{Q} = \frac{5}{2}\frac{dh}{h}$, (b) $\frac{dQ}{Q} = \frac{3}{2}\frac{dh}{h}$, (c) $\frac{dQ}{Q} = \frac{7}{2}\frac{dh}{h}$, (d) $\frac{dQ}{Q} = \frac{1}{2}\frac{dh}{h}$.

11. The discharge over a rectangular notch taking into velocity of approach is given by

(a) $Q = \frac{2}{3} C_d\, b \sqrt{2g}\ (H^{1.5} - h_a^{1.5})$, (b) $Q = \frac{2}{3} C_d\, b \sqrt{2g}\ (H - h_a)^{1.5}$,

(c) $Q = \frac{2}{3} C_d\, b \sqrt{2g}\ \left[(H + h_a)^{1.5} - (h_a)^{1.5}\right]$, (d) none of the above.

12. The velocity of approach is given by

(a) $v_a = \frac{Q}{\text{Area of notch}}$, (b) $v_a = \frac{Q}{\text{Area of channel}}$,

(c) $v_a = \frac{Q}{\text{Width of channel} \times \text{head of notch}}$, (d) none of the above.

13. The width of nappe of a rectangular weir is given by

(a) $b - 0.1$ nH, (b) $b + 0.1$ nH, (c) $b - \frac{0.1H}{n}$, (d) $H - 0.1$ nb.

14. The velocity with which water approaches a weir is called

(a) Velocity of flow, (b) Velocity of approach, (c) Velocity of nappy, (d) none of the above.

15. A drowned weir is that weir in which

(a) The downstream water level is below the upstream water level,
(b) The downstream water level is same as that of upstream water level,
(c) The downstream water level is above the upstream water level,
(d) none of the above.

16. The maximum discharge over broad crested weir is given by

(a) $Q_{max} = 7.105\, C_d\, b\, (H)^{1.5}$, (b) $Q_{max} = 1.705\, C_d\, b\, (H)^{1.5}$,
(c) $Q_{max} = 7.105\, C_d\, b\, (H)^{2.5}$, (d) $Q_{max} = 1.705\, C_d\, b\, (H)^{2.5}$.

17. The discharge (L/min) in a 90° V-notch having $C_d = 0.58$ under a head of 10 cm is

(a) 260, (b) 130, (c) 310, (d) 1.73.

18. In a triangular notch there is an error of 4 % in observing the head. The error in the computed discharge is

(a) 4 %, (b) 6 %, (c) 10 %, (d) 2.5 %.

19. In a suppressed rectangular weir the discharged was found to be 3 % in excess of the actual discharge. This was due to an error in reading the head the measured head was

(a) 3 % excess, (b) 2 % less (c) 2% excess, (d) 1.2 % excess.

20. In a 90° V-notch for the given head the error in the estimated discharge due to 2% error in the measurement of the vertex angle is

(a) π%, (b) 5%, (c) $\frac{\pi}{2}$ %, (d) $\frac{3\pi}{n}$%.

21. The discharges in a triangular notch and a suppressed rectangular weir both having the same head and C_d are identical when the ratio of the water surface width in the V-notch to the width of the rectangular weir is

(a) 1, (b) 2.5, (c) 1.5, (d) 1.125.

22. If the discharge over a 90% V- notch is given by

$$Q = 1.37\, (H)^{2.5} \text{ where } Q \text{ is in m}^3\text{/s and } H \text{ is in meters}$$

Then the C_d is given by

(a) 0.611, (b) 0.46, (c) 0.71, (d) 0.58.

23. In a rectangular suppressed weir the tail water head is 30% of the upstream head both measured above the crest. The submerged flow discharge is x% of the free flow at the same upstream head where x is

(a) 98.1%, (b) 70%, (c) 87.7%, (d) 93.3%.

24. While conducting flow measurement using a rectangular notch an error of 2% in head over the notch and an error of – 3% in the width of the notch occurred. The percentage error in the computed discharge would be

(a) + 6%, (b) – 2.5%, (c) 0%, (d) – 1%.

ANSWERS

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

nozzle of 20 cm diameter is fitted at the end of the pipe. Find the power of the jet. Assume coefficient of water coming out of jet = 0.98 and coefficient of friction of the pipe = 0.006.

(Ans. 10890 kW)

13.39. A nozzle is fitted at the discharge end of the pipe whose diameter is 7.5 cm and length is 250 m. The head available at the inlet of the pipe is 40 m. Determine the maximum power transmitted by the nozzle. Take $f = 0.01$ for the pipe and neglect the minor losses.

Hint: $d = \left(\frac{D^5}{2fL}\right)^{\frac{1}{4}}$ for maximum power. **(Ans.** 1.6 kW)

13.40. A nozzle of 15 cm in diameter is fitted to the end of a pipe of 3500 m long and 50 cm diam. If the head of water at the entry of the pipe is 75 m, find the velocity of water through the nozzle and discharge. Take $f = 0.007$. **(Ans.** 8.9 m/s, 157 L/s)

13.41. A nozzle of 10 cm is fitted to the end of pipeline whose diameter is 25 cm. Pressure at the inlet of the nozzle is 75 kPa. If the actual discharge of water through nozzle is 0.05 m³/sec, find coefficient of discharge of the nozzle $\left(C_d = \frac{\text{actual discharge}}{\text{theoretical discharge}}\right)$. **(Ans.** 0.51)

13.42. Water at the rate of 0.6 m³/s under the head of 300 m is supplied to the water turbine through a pipe line 35 cm diam. and 4000 m long. The nozzle fitted at the end of the pipe line has a diameter 15 cm. Find the power input to the water turbine.

Hint: Power output of nozzle = Power input to water turbine.

(Ans. $v = 69.3$ m/s, $Q = 1.22$ m³/s, $P = 2937$ kW).

13.43. A wrought-iron pipe 30 cm in diameter and 560 m long delivers water 100 m below the water surface in the tank. Determine the diameter of the nozzle which will deliver maximum power. Take $f = 0.005$ and $C_v = 0.97$ for nozzle.

13.44. A water head supplying water to a pipe line of 20 cm in diameter and 600 m long is 200 m. Determine the nozzle diameter fitted to the end of pipe so that the power transmitted is maximum. Also find out maximum power. **(Ans.** 5.8 cm, 179.5 kW)

OTHERS

13.45. An overhead tank of 7.2 m × 3.6 m is 1.8 m deep and it is full of water. It is to be emptied by a vertical pipe of 10 cm diameter and 7.5 m height and having its lower end discharging into a sump in which water level is always 6 m below the bottom of the tank. Find the time required to empty the overhead tank. Take $f = 0.006$.

Hint: $H_1 = 1.8 + 6 = 7.8$ m and $H_2 = 6$ m. **(Ans.** 9.31 seconds)

OBJECTIVE TYPE QUESTIONS

Identify the Correct Answer

1. The head loss due to friction is governed by
   (a) Froude's Law (b) Chezy's Law (c) Darcy's Law (d) None of the above.
2. The velocity of flow through a pipeline according to Chezy's formula is given by
   (a) $v = m\sqrt{Ci}$ (b) $v = i\sqrt{mC}$ (c) $v = \frac{1}{e}\sqrt{mi}$ (d) $v = C\sqrt{mi}$
3. If the velocity v_1 changes to v_2 in a pipe when the diameter d_1 suddenly changes to d_2 $(d_2 > d_1)$, then the loss of head is given by
   (a) $\frac{v_1^2 - v_2^2}{2g}$ (b) $\frac{2(v_1 - v_2)}{g}$ (c) $\frac{(v_1 - v_2)^2}{2g}$ (d) $\frac{v_1 - v_2}{2g}$
4. The head loss due to sudden contraction in the pipe line is given as $K\frac{v^2}{2g}$ where K is given by
   (a) $\left(\frac{1}{C_c} - 1\right)^2$ (b) $\left(\frac{1}{C_c} - 1\right)$ (c) $1 - \frac{1}{C_c}$ (d) $\frac{1}{C_c^2} - 1$.

5. In a uniform diameter of a pipeline, the loss of head at exit is
   (a) One-half that at inlet
   (b) Same as that at inlet
   (c) Twice that at inlet
   (d) Four times that of inlet.
6. The HGL is
   (a) Sometimes above TEL
   (b) Velocity head below TEL
   (c) Velocity head above TEL
   (d) None of the above.
7. HGL for horizontal pipeline of uniform diameter is a
   (a) Straight line parallel to the axis of the pipeline
   (b) Straight line gradually sloping downwards towards the direction of flow
   (c) Curved line sloping towards the direction of flow
   (d) None of the above.
8. The head loss in sudden expansion from 6 cm diam. to 12 cm diameter pipe is given by
   (a) $\frac{15}{16} v_1^2$
   (b) $\frac{3}{4}\left(\frac{v_1^2}{2g}\right)$
   (c) $\frac{1}{4} \frac{v_1^2}{2g}$
   (d) $\frac{9}{16} \cdot \frac{v_1^2}{2g}$,

   where v_1 is the velocity in 6 cm. diam. pipe.
9. In a sudden contraction, the velocity head changes from 0.5 m to 1.25 m. The coefficient of contraction is 0.67. The head loss due to contraction is
   (a) 0.133 m
   (b) 0.332 m
   (c) 0.644 m
   (d) 0.266 m.
10. The HGL represents the sum of
    (a) Pressure head and kinetic head
    (b) Kinetic head and datum head
    (c) Pressure head and datum head
    (d) Pressure head, kinetic head and datum head.
11. The TEL represents the sum of
    (a) Pressure head and kinetic head
    (b) Kinetic head and datum head
    (c) Pressure head and datum head
    (d) Pressure head, kinetic head and datum head.
12. When two pipes are arranged in series
    (a) The flow rate may be different in two pipes
    (b) The head loss per unit length must be more in the smaller pipe
    (c) The velocity of flow must be same in both pipes
    (d) The head loss must be same in both pipes.
13. In a parallel pipe system
    (a) The flow must be equal in all pipes
    (b) The head loss per unit length must be same for all pipes
    (c) The head loss across each of parallel pipes must be same
    (d) None of the above.
14. A pipe is replaced by two parallel pipes, each with same cross-sectional area which is half of the cross-sectional area of the original, then the discharge will
    (a) Remains same
    (b) Increase by more than 10%
    (c) Decrease by more than 10%
    (d) None of the above.
15. It is required to carry the same discharge by replacing of a pipe of diam. D by two equal parallel pipes of diam. d, then (d/D) should be
    (a) 0.37
    (b) 0.42
    (c) 0.76
    (d) 0.56.
16. A pipeline is said to be equivalent to another pipeline if in both
    (a) The length and discharge are same
    (b) The velocity and diameter are same
    (c) The discharge and pressure head loss are same
    (d) The length and diameter are same.
17. For the pipes connected in series
    (a) $v = v_1 + v_2 + ...$
    (b) $f = f_1 + f_2 + ...$
    (c) $Q = Q_1 + Q_2 + ...$
    (d) $h_f = h_{f_1} + h_{f_2} + ...$

18. For the pipes connected in parallel
(a) $v = v_1 + v_2 + ...$ (b) $f = f_1 + f_2 + ...$ (c) $Q = Q_1 + Q_2 + ...$ (d) $h_f = h_{f_1} + h_{f_2} + ...$

19. When the pipes are connected in series, the total rate of flow is
(a) Equal to sum of the flow rate in each pipe
(b) Equal to sum of the reciprocal of flow rate in each pipe
(c) Same as flowing through each pipe
(d) None of the above.

20. Two identical pipes of length L, diam. d and friction factor f are connected in series between two reservoirs. The size of a pipe of length L and of the same friction factor f, equivalent to above pipe line is
(a) 0.5 d (b) 1.4 d (c) 1.2 d (d) 0.87 d.

21. Two identical pipes of length L, diam. d and friction factor f are connected in parallel between two reservoirs. The size of the pipe of length L and same friction factor f equivalent to above pipe, is
(a) 1.4 d (b) 0.87 d (c) 2 d (d) 0.5 d.

22. A pipe line connecting two reservoirs has its diam reduced by 10% over a length of time due to deposit. If the friction factor is same, for the given head difference in the reservoirs, this would reflect in reduction in discharge of
(a) 11.6 % (b) 23.2 % (c) 32.2 % (d) 16.1 %.

23. Two pipe lines of 20 cm and 30 cm diameters and of equal length are connected parallel between two reservoirs. If f is same for both pipe lines, the ratio of discharge in 20 cm line to discharge in 30 cm line is
(a) 0.363 (b) 0.726 (c) 0.1815 (d) 0.555.

24. Two reservoirs are connected by two pipes A and B having same length and f in series. If the diameter of A is 30% greater than of B, then the ratio of head loss in A to head loss in B is
(a) 0.84 (b) 0.65 (c) 0.27 (d) 0.15.

25. Two reservoirs having head difference H are connected by a pipe having friction factor f. If H and f are going to be same, and the flow is to be increased by 100%, the increase in cross-sectional area of the pipe required is
(a) 74 % (b) 20 % (c) 43 % (d) 35 %.

26. For maximum transmission of power through a pipeline with total head H, the head loss due to friction (h_f) is.
(a) $\frac{H}{3}$ (b) $\frac{H}{2}$ (c) $\frac{2}{3}H$ (d) $\frac{H}{5}$

27. A pipe connecting two reservoirs is said to be a syphon, if
(a) It can discharge liquid at fast rate
(b) Its exit is at lower level than its inlet
(c) It has subatmospheric pressure in it
(d) None of the above.

28. The pressure of water at the outlet of the nozzle is
(a) Atmospheric (b) Below atmosphere (c) Above atmosphere.

ANSWERS

1. (a)	2. (d)	3. (c)	4. (a)	5. (c)	6. (b)	7. (b)	8. (d)
9. (b)	10. (c)	11. (d)	12. (b)	13. (c)	14. (c)	15. (c)	16. (c)
17. (d)	18. (c)	19. (c)	20. (d)	21. (a)	22. (b)	23. (a)	24. (c)
25. (a)	26. (a)	27. (c)	28. (a).				

OBJECTIVE QUESTIONS

1. The drag force on a body is due to
   (a) shear stress on the surface, (b) pressure on the surface,
   (c) the separation of flow over the body, (d) the shear stress and pressure on the body.
2. Stokes law for the drag-force on a small sphere moving in a uniform flow field is valid for Reynold number upto about
   (a) 1, (b) 100, (c) 0.1, (d) 10^5.
3. In stoke equation $F_D = 3\pi\mu D U$, the ratio of form drag to viscous drag is
   (a) 1:2, (b) 2:1, (c) 3:1, (d) 1:3.
4. The sudden drop in the value of C_D occurs in case of flow around a sphere at a Reynold number of about
   (a) 0.1, (b) 1, (c) 1000, (d) 2×10^5.
5. A flat plate held normal to the flow causes a drag which is due to
   (a) skin friction over the plate, (b) pressure difference on the two sides of the plate,
   (c) skin friction and pressure differences, (d) none of the above.
6. The lift force on a unit length of cylinder varies as
   (a) its diameter, (b) density of the fluid,
   (c) velocity of the fluid, (d) circulation around it,
   (e) all (a), (b) and (c), (f) all (b), (c) and (d), (g) all (a), (b), (c) and (d).
7. The actual lift coefficient of a body is less than its theoretical value because
   (a) fluid is treated as incompressible, (b) the fluid is considered ideal,
   (c) the flow is not uniform, (d) the size of the body is not entering into the equation.
8. The lift force on an aerofoil is due to
   (a) the irrotional flow around it, (b) the creation of circulation around it,
   (c) the separation of the flow over the body, (d) none of the above.
9. At stall point of the aerofoil
   (a) the lift is maximum and drag is minimum, (b) the drag is maximum and lift is minimum,
   (c) the lift is maximum and drag increases steeply beyond it,
   (d) the ratio F_L/F_D is maximum.
10. The angle of attack for an aerofoil is around
    (a) $-5°$, (b) $0°$, (c) $+10°$, (d) $15°$.
11. The lift on a immersed body in a fluid stream is
    (a) due to buoyant force,
    (b) the dynamic fluid force component normal to the approach velocity,
    (c) the resultant fluid force on the body,
    (d) none of the above.
12. The pressure drag results from
    (a) skin friction, (b) occurrence of wake,
    (c) deformation drag, (d) none of the above.
13. At Re = 2×10^5, there is sudden drop in the value of C_D of cylinder, because
    (a) of separation of flow,
    (b) of shift of the point of separation down stream,
    (c) of boundary layer control, (d) none of the above.
14. A drag is defined as a force exerted by a flowing fluid on a solid body
    (a) in the direction of flow, (b) perpendicular to the direction of flow,
    (c) in the direction which makes 45° angle to the flow direction,
    (d) none of the above.

15. The lift force is defined as a force exerted by a flowing fluid on a solid body
(a) in the direction of flow, (b) perpendicular to direction of flow.
(c) at an angle 45° to the direction of flow
(d) None of the above

16. The terminal velocity of a falling body is equal to
(a) a maximum velocity with which body will fall,
(b) the maximum constant velocity with which body will fall,
(c) 50% of maximum velocity,
(d) none of the above.

17. When a falling body has attained a terminal velocity, the weight of the body is given by
(a) $W = F_D - F_b$, (b) $W = F_D + F_b$, (c) $W = F_b - F_D$ (d) None of the above.
where W, F_D and F_b are weight of the body, drag-force on the body and buoyant force on the body respectively.

18. The tangential velocity of an ideal fluid at any point on the surface of the cylinder is given by
(a) $v_\theta = 2U \sin\theta$, (b) $v_\theta = \frac{1}{2} U \sin\theta$, (c) $v_\theta = U \sin\theta$ (d) None of the above.

19. The lift force (F_D) on a rotating circular cylinder in a uniform flow of velocity U is given by
(a) $F_L = \frac{LU\Gamma}{\rho}$, (b) $F_L = \frac{\rho LU}{\Gamma}$, (c) $F_L = \rho L U \Gamma$, (d) $F_L = \frac{\rho L \Gamma}{U}$

20. The lift coefficient C_L for a rotating cylinder in a uniform flow is given by
(a) $C_L = \frac{U\Gamma}{R}$, (b) $C_L = \frac{\Gamma}{RU}$, (c) $C_L = \frac{\Gamma R}{U}$, (d) $C_L = \frac{RU}{\Gamma}$.

21. In calculating the lift force
(a) always frontal area is used,
(b) actual surface area of the body is used,
(c) planform area is used if the body is in lifting surface,
(d) none of the above.

22. A power used by an automobile to overcome the wind resistance is 1.5 kN when travelling at 60 km/h. If it travels at 90 km/h, then the power used for overcoming wind resistance in kW is
(a) 7.6, (b) 3.38, (c) 2.5, (d) 5.06,

23. The drag-force (F_D) is expressed by an equation
(a) $F_D = C_D A . \rho U^2$, (b) $F_D = 2C_D . A . \rho U^2$, (c) $F_D = C_D . A . \frac{\rho U^2}{2}$, (d) None of the above.

24. The lift-force is expressed by an equation
(a) $F_L = C_L A . \rho U^2$, (b) $F_L = 2C_L A . \rho U^2$,
(c) $F_L = C_L . A . \frac{\rho U^2}{2}$, (d) None of the above.

25. Total drag on a body is sum of
(a) pressure drag and velocity drag, (b) friction drag and velocity drag,
(c) pressure drag and friction drag, (d) none of the above.

26. A body is called stream lined body when it is placed in the flow and the surface of the body
(a) coincides with stream lines, (b) does not coincide with stream lines,
(c) is perpendicular to stream lines, (d) none of the above.

27. A drag force on the sphere (F_D) when Re < 1, is given by
(a) $F_D = 3\pi\mu D U$, (b) $F_D = 5\pi\mu D U$, (c) $F_D = \pi\mu D U$, (d) $F_D = 2\pi\mu D U$.

28. The skin friction drag on a sphere when Re < 1, is equal to
(a) 1/3 of total drag (b) half of total drag (c) 2/3 of total drag, (d) none of the above.

29. The pressure drag on a sphere when Re < 1, is equal to
(a) 1/2 of total drag (b) 2/3 of total drag (c) 1/3 of total drag, (d) none of the above.

30. For a sphere falling at terminal velocity in the stoke's law range; the drag coefficient C_D is given by
(a) 24 Re, (b) $\frac{24}{\text{Re}}$, (c) $\frac{64}{\text{Re}}$, (d) none of the above.

31. Stoke's law is valid upto a maximum Reynold's number of
(a) 1.0, (b) 0.1, (c) 5×10^5 (d) 2000,

32. For a spherical sand particle in the stoke's law range, the fall velocity U is related to the diameter D as
(a) U increases as D, (b) U varies inversely as D,
(c) U varies as D^2, (d) U varies as $\sqrt{D}$.

33. In very low Reynold's number flow, the deformation drag
(a) consists of frictional drag only,
(b) consists of pressure, drag only
(c) consists of both friction and pressure drags,
(d) is essentially zero.

34. In flow past the bluff-body
(a) the frictional drag is larger than the pressure drag,
(b) the pressure drag forms considerably large portion of the total drag,
(c) the frictional drag forms considerably small portion of the total drag,
(d) none of the above.

35. The approximate value of drag coefficient (C_D) of hemispherical parachute is
(a) 0.33, (b) 1.33, (c) 0.23, (d) 2.3.

36. A large circular cylinder located in a flow whose Re > 5×10^5 will have a drag-coefficient C_D
(a) 1.2, (b) 2.1, (c) 0.33, (d) 3.3.

37. A drag-coefficient C_D of a sphere undergoes a sudden drop at the critical Reynold's number of about
(a) 1, (b) 2000, (c) 2×10^5, (d) 5×10^6.

38. The drag-coefficient C_D of a circular cylinder undergoes a sudden drop at the critical Reynold's number of about
(a) 5×10^5, (b) 5×10^6, (c) 2000, (d) 1.0.

ANSWERS

1. (a),	2. (a),	3. (a),	4. (d),	5. (b),	6. (f),
7. (b),	8. (c),	9. (c),	10. (c),	11. (b),	12. (b),
13. (b),	14. (a),	15. (b),	16. (b),	17. (b),	18. (a),
19. (c),	20. (b),	21. (c),	22. (d),	23. (c),	24. (c),
25. (c),	26. (a),	27. (a),	28. (c),	29. (c),	30. (b),
31. (a),	32. (c),	33. (c),	34. (b),	35. (b),	36. (c),
37. (c),	38. (a).				

(C_3) OTHER NON-DIMENSIONAL NUMBERS

15.50. A model is to be built for the flow where gravity and surface tension exist. Determine the length scale ratio which will insure complete dynamic similitude.

(*b*) A prototype of above phenomenon is 16.5 cm long and moves with an velocity 4 m/s in water (σ = 0.0736 N/m). The model is to be tested in ethyle alcohol (sp. gr. = 0.79) and (σ = 0.0216 N/m). Determine the length and velocity of model. [**Hint :** $(F_N)_r = (W_N)_r$ for dynamic similitude].

(Ans. L_r = 0.61, L_m = 10 cm, v_m = 3.12 m/s**)**

15.51. A wave making resistance of a hall of flying boat at a speed of 31 m/s on sea water is to be estimated from experiment in fresh water tank on a model of $\frac{1}{10}$ th of full size. Find the best speed for the test and amount of drag on the model if the estimated full scale wave resistance is 6 kN.

Take ρ (sea water) = 1030 kg/m^3. **(Ans. 9.8 m/s, 5.85 N)**

15.52. A spillway model is built $\frac{1}{30}$ of full scale and 1.5 wide. The prototype is 15 m high and maximum head expected is 2 m. Find the height of the model and head also (*b*) If the head and flow over the model are 15 cm and 20 L/s. Find the flow per meter of prototype.

(Ans. (*a*) 40 cm, 5 cm (*b*) 1160 L/s**)**.

15.53. A model of a reservoir is drained in 6 minutes by opening a sluice gate. How long should it take to empty the prototype where model is $\frac{1}{256}$ of prototype. **(Ans. 96 minutes)**

15.54. A model of river boat $\frac{1}{16}$ of prototype is towed in water (ν = 0.0115 cm^2/s). What would be the speed of the model to simulate a speed of 16 m/s. If the resistance is due to (*a*) friction only (*b*) waves only. Calculate the value of ν required in which model to be tested if the resistance is due to both friction and gravity. **(Ans. 256 m/s, 4 m/s, 1.8 × 10^{-4} cm^2/s)**

15.55. A fan is designed to deliver 5.5 m^3/s where air density is 0.95 kg/m^3 against a static resistance 4.5 cm of water with a η = 70%. Calculate the output, pressure rise and power required at the site where air density is 1.25 kg/m^3 **(Ans. 5.5 m^3/s, 6 cm ; 5.1 kW)**

OBJECTIVE TYPE QUESTIONS

1. Which of the following is a dimensionally homogeneous equation.

   (*a*) $Q = A\sqrt{2gH}$ (*b*) $S = ut - \frac{1}{2}t^2$

   (*c*) $P = \frac{wQH}{1000}$ (*d*) None of the above.

2. The minimum number of fundamental units entering into any physical problem is

   (*a*) 1 (*b*) 2 (*c*) 3 (*d*) 4.

3. Buckingham π-theorem stipulates that the number of dimensionless group is

   (*a*) $n - m$ (*b*) $m - n$ (*c*) $(n + m)$ (*d*) $\frac{n}{m}$.

   where n is number of Physical Parameters controlling the phenomenon involving m fundamental dimension.

4. The number of fundamental dimensions in a phenomenon controlled by variables Q (flow rate), H (head), g (gravitational acceleration) v (velocity) and W (width) is

   (*a*) 2 (*b*) 3 (*c*) 4 (*d*) 5.

5. For the above problem, which of the following is non-dimensional parameter

   (*a*) $\frac{Q^2}{gH^4}$ (*b*) $\frac{v^2}{g^2Q}$ (*c*) $\frac{Q}{\sqrt{gH}}$ (*d*) $\frac{Q}{(\sqrt{2gH})B}$.

6. Which term among the following represents Reynold number ?

(a) $\frac{vL}{\nu}$ (b) $\frac{vL\mu}{\rho}$ (c) $\frac{v}{\sqrt{gL}}$ (d) $\frac{\Delta p}{gv^2}$.

7. Which of the following is not dimensionless ?

(a) Coefficient of discharge (b) Kinematic viscosity
(c) Reynold number (d) Mach number.

8. The Reynold number is defined as a ratio of

(a) Viscous forces to inertia forces (b) Intertia forces to viscous forces
(c) Inertia forces to gravitational forces (d) Gravitational forces to inertia forces.

9. The Reynold number plays an important role in

(a) Flow through pipe (b) Flow through channel
(c) Waves in the sea (d) Sheet flow.

10. In the study of forces acting on Aeroplane flying with supersonic velocity ; the number plays important role.

(a) Re (b) F_N (c) W_N (d) M_N (e) E_N.

11. A dimensionless combination of ρ, L, Q and Δp is

(a) $\sqrt{\frac{\Delta p}{\rho}} \cdot \frac{Q}{L^2}$ (b) $\frac{\rho Q}{\Delta p\, L^2}$ (c) $\sqrt{\frac{\rho}{\Delta p}} \cdot \frac{Q}{L^2}$ (d) $\frac{\Delta \rho L Q}{\rho}$.

12. Which of the following non-dimensional number is considered for studying river model

(a) Re (b) F_N (c) W_N (d) E_N.

13. The velocity at a point in a model oil pipe is found as 1.5 cm/s under laminar flow condition. If the model is $\frac{1}{5}$ of prototype, the corresponding velocity in the prototype (cm/s) is

(a) 7.5 (b) 0.75 (c) 5.7 (d) 0.57.

14. The discharge scale ratio for Froude law is

(a) $(L_r)^{2.5}$ (b) $(L_r)^{3.5}$ (c) $(L_r)^{0.5}$ (d) $(L_r)^3$.

15. The force scale ratio for Reynold law using the same fluid in model and prototype is

(a) L_r^2 (b) $\sqrt{L_r}$ (c) L_r^3 (d) 1.

16. The Pressure at a point in a spillway model of $\frac{1}{10}$ of prototype is p, the pressure in the prototype will be

(a) p (b) $100\,p$ (c) $10\,p$ (d) None of the above.

17. The dimensions of surface tension σ are

(a) ML^{-1} (b) MT^{-2} (c) $ML^{-1}T^{-2}$ (d) $ML^{-2}T^{-1}$.

18. The Euler number E_N is given by

(a) $\frac{v}{\sqrt{\frac{K}{\rho}}}$ (b) $\frac{v}{\sqrt{\frac{\Delta p}{\rho}}}$ (c) $\frac{v\rho}{\sqrt{\Delta p}}$ (d) $\frac{\rho L v^2}{\sigma}$

19. The time scale ratio for a model based on. Froude law in terms of length scale $L_r = \left(\frac{L_p}{L_m}\right)$ is

(a) L_r (b) $\sqrt{L_r}$ (c) $\frac{1}{\sqrt{L_r}}$ (d) $(L_r)^{1.5}$.

20. If a Froud Law is used, then acceleration ratio a_r is equal to

(a) L_r^2 (b) $\frac{1}{L_r^2}$ (c) 1 (d) $\frac{1}{L_r}$

21. If the same fluid is used in model and prototype and it is desired to have same Reynold and Froud number in model and prototype, then the scale ratio $\left(\frac{L_p}{L_m}\right)$ is

(a) v_r (b) $\sqrt{v_r}$ (c) $\frac{1}{\sqrt{v_r}}$ (d) 1.

22. If the Reynold law is used for model and prototype using the same liquid then the discharge ratio (Q_r) is given by

(a) L_r (b) L_r^3 (c) 1 (d) $\sqrt{L_r}$.

23. If a Reynold law is used for Model and Prototype then the force ratio $F_r = \left(\frac{F_m}{F_p}\right)$ is equal to

(a) $\rho_r L_r^3$ (b) $\frac{\mu_r^2}{\rho_r}$ (c) $L_r \frac{\mu_r}{\rho_r}$ (d) $\frac{\mu_r}{L_r^2 \rho_r}$.

where $\rho_r = \frac{\rho_m}{\rho_p}$, $L_r = \frac{L_m}{L_p}$, $\mu_r = \frac{\mu_m}{\mu_p}$.

24. The ratio of inertia force to viscous force is known as
(a) Reynold number (b) Froud number
(c) Mach number (d) Euler number.

25. The square root of ratio of inertia force to gravity force is known as
(a) Reynold number (b) Froud number
(c) Mach number (d) Euler number.

26. The square root of ratio of inertia force to force due to compressibility is known as
(a) Reynold number (b) Froud number
(c) Mach number (d) Euler number.

27. The square root of ratio of inertia force to pressure force is known as
(a) Reynold number (b) Froud number
(c) Mach number (d) Euler number.

28. Model analysis of pipe flow is based on
(a) Reynold number (b) Froud number
(c) Mach number (d) Euler number.

29. Model analysis of free surface flow is based on
(a) Reynold number (b) Froud number
(c) Mach number (d) Euler number.

30. Model analysis of a projectile moving with supersonic velocity is based on
(a) Reynold number (b) Froud number
(c) Mach number (d) Euler number.

ANSWERS

1. (c)	2. (b)	3. (a)	4. (a)	5. (a)
6. (a)	7. (b)	8. (b)	9. (a)	10. (d)
11. (c)	12. (–)	13. (a)	14. (a)	15. (d)
16. (c)	17. (b)	18. (b)	19. (c)	20. (c)
21. (d)	22. (c)	23. (b)	24. (a)	25. (b)
26. (c)	27. (d)	28. (a)	29. (b)	30. (c)

6.26. Find the air mass flow rate passing through a horizontal venturimeter having inlet of 10 cm diameter and throat of 5 cm diameter. The absolute pressure at the inlet and throat were 4.4 bar and 3.43 bar. Take $\gamma = 1.4$ and $R = 287$ Nm/kg-K for air.

6.27. Find the mass flow rate of H_2 through a horizontal venturimeter having inlet and throat diameters of 20 cm and 5 cm. The pressure gauges fitted to inlet and throat have registered 3.92 bar and 3.43 bar. The temperature at inlet = 296 K. R (for H_2) = 4133 Nm/kg-K.

6.28. A venturimeter of 2.5 cm in diameter is installed in a pipe of 7.5 cm diameter carrying air. The inlet and throat pressures are 130 kN/m^2 and 104 kN/m^2 respectively. Find the mass flow rate through the venturi assuming the flow is adiabatic. Take air temperature = 20°C, $\gamma = 1.4$ and $R = 287$ Nm/kg-K. (**Ans.** 0.125 kg/sec)

6.29. In a wind tunnel, a model was tested and gauges connected to the pitot tube gave reading for its static and stagnation pressure as 2.5 cm and 13.1 cm of water. Find the velocity of air in the test section if barometer reads 76 cm of Hg and atmospheric temperature is 28°C. (**Ans.** 42.5 m/s)

6.30. In a test section of wind tunnel, a pitot tube indicated static pressure of 78.5 kN/m^2 and the difference between the stagnation and static pressure was 11 cm of Hg. Find the Mach number and velocity of air if barometer reads 76 cm of Hg and stagnation temperature is 42°C.

(0.354, 130 m/s)

6.31. A pitot tube is used to measure the velocity in a test section of a wind tunnel. The manometer connected to stagnation tube reads 11.2 cm of water head (gauge) and static gauge pressure is 2.2 cm of water. The atmospheric pressure and temperature are 101 kN/m^2 and 24°C. Find the air velocity in test section. (**Ans.** 4.34 m/s)

6.32. Air flow in a duct is measured by a pitot tube. The static pressure recorded is 50 kPa (ab) and stagnation pressure was found as 95 kPa (ab). The recorded stagnation temperature is 30°C. Find the velocity of air (*i*) considering compressibility effect (*ii*) neglecting compressibility effects. Take $\gamma = 1.4$ and $R = 287$ Nm/kg-K for air. (**Ans.** 319.5 m/s and 287 m/s)

OBJECTIVE QUESTIONS

1. The speed of sound in an ideal fluid varies
   (*a*) Directly as the mass density (*b*) Inversely as the square root of mass density
   (*c*) Directly as the bulk modulus (*d*) Inversely as the square root of bulk modulus.
2. If the Mach number is 0.4, the compressibility correction factor is about
   (*a*) 1.01 (*b*) 1.04 (*c*) 1.004 (*d*) 1.001.
3. If the semi-vertex angle α of the Mach cone is 3°, the Mach number is
   (*a*) $\sqrt{\frac{1}{2}}$ (*b*) $\sqrt{\frac{1}{3}}$ (*c*) 3 (*d*) 2.
4. The critical pressure ratio for air under adiabatic flow is about
   (*a*) 0.528 (*b*) 0.728 (*c*) 0.638 (*d*) 0.438.
5. Which expression does not give the speed of sound
   (*a*) $\sqrt{\gamma RT}$ (*b*) $\sqrt{\frac{dp}{d\rho}}$ (*c*) $\sqrt{\frac{K}{\rho}}$ (*d*) $\sqrt{\frac{p}{\rho^{\gamma}}}$
6. Effect of compressibility of fluid can be neglected if
   (*a*) $M = 1$ (*b*) $M > 1$ (*c*) $M < 1$ but > 0.4 (*d*) $M < 0.4$.
7. Adiabatic process is represented by
   (*a*) $\frac{p}{\rho} = C_1$ (*b*) $\frac{p}{\rho^{\gamma}} = C_1$ (*c*) $p\rho = C_1$ (*d*) $p\rho^{\gamma} = C_1$.

8. The Mach number is the ratio of

(a) Inertia force and elastic force
(b) Inertia force and gravitational force
(c) Inertia force and viscous force
(d) Inertia force and pressure force.

9. Mach angle is denoted by

(a) $\sin^{-1}(M)$
(b) $\sin^{-1}\left(\frac{1}{M}\right)$
(c) $\tan^{-1}(M)$
(d) $\tan^{-1}\left(\frac{1}{M}\right)$

10. The stagnation temperature T_o of a fluid flowing with a velocity v is given by

(a) $T + v^2$
(b) $T + \frac{v^2}{2g}$
(c) $T + \frac{v^2}{2gC_p}$
(d) $T + \frac{v^2}{2gC_v}$.

The general continuity equation is given by

(a) $d\left(p + \frac{\rho v^2}{2}\right) = 0$
(b) $d\left(p + \frac{\rho v^2}{2} + Z\right) = 0$
(c) $\frac{dp}{p} + v\,dv = 0$
(d) $\frac{dp}{\rho} + \frac{dv}{v} + \frac{dA}{A} = 0$.

11. The differential form of energy equation for adiabatic flow is

(a) $d(p) + d(\rho v^2) = 0$
(b) $\frac{dv}{v} + \frac{d\rho}{\rho} + \frac{dA}{A} = 0$
(c) $v\,dv + \frac{dp}{\rho} = 0$
(d) None of the above.

12. The area-velocity relationship for compressible fluid is given by

(a) $\frac{dA}{A} = \frac{dv}{v}(M^2 - 1)$
(b) $\frac{dA}{A} = \frac{dv}{v}(C^2 - 1)$
(c) $\frac{dA}{A} = \frac{dv}{v}(1 - v^2)$
(d) $\frac{dA}{A} = \frac{dv}{v}(1 - M^2)$

13. A gas has a molecular weight of 44. The gas constant R for the gas in Nm/kg-K is

(a) 0.189 (b) 189 (c) 18.9 (d) 1890.

14. A gas has a molecular weight of 16 and its C_v = 1730 J/kg-K. The value of γ for the gas is

(a) 1.4 (b) 1.3 (c) 1.66 (d) 1.2.

15. The speed of sound in air varies as

(a) $\sqrt{p}$
(b) $\sqrt{T}$
(c) $\frac{1}{\sqrt{p}}$
(d) $\frac{1}{\sqrt{T}}$.

where p and T are absolute pressure and absolute temperature.

16. In a atmosphere where p = 16.5 kN/m^2 (ab) and ρ = 0.265 kg/m^3 and γ = 1.4, the speed of sound is

(a) 29.5 m/s (b) 2.95 m/s (c) 295 m/s (d) 78.5 m/s

17. In a atmosphere, the speed of sound is 300 m/s. If the plane travels at 1620 km/hr in this atmosphere, the Mach angle is

(a) 30.5° (b) 35° (c) 41.8° (d) 48.1°.

18. In air flow (γ = 1.4) in a duct, the ambient temperature is 30°C and measured stagnation temperature is 59.7°. The Mach number of the flow is

(a) 0.5 (b) 0.6 (c) 0.7 (d) 1.3.

19. Air (γ = 1.4) flows through a duct at a Mach number of 1.5. If the ambient temperature is 280 K, the stagnation temperature becomes

(a) 406 K (b) 604 K (c) 306 K (d) 407 K.

20. Air (γ = 1.4 and R 287 Nm/kg-k) at 292 K is expanded adiabatically, the maximum velocity that can be achieved is

(*a*) 667 m/s (*b*) 766 m/s (*c*) 676 m/s (*d*) 566 m/s.

21. For isentropic flow of air (γ = 1.4), the static temperature T and stagnation temperature T_o at any Mach number are related as T_o/T =

(*a*) $(1 + 0.2M^2)$ (*b*) $(1 + 0.2M^2)^{1.5}$ (*c*) $(1 + 0.2M^2)^{0.5}$ (*d*) $(1 + 0.2M^2)^{-0.5}$

22. For helium (γ = 1.66), the critical pressure ratio is

(*a*) 0.488 (*b*) 0.528 (*c*) 0.688 (*d*) 0.838.

23. In an adiabatic flow of air (γ = 1.4) the stagnation temperature is 300 K. If at a section, the temperature is 166.7 K, the Mach number of the flow is

(*a*) 2.0 (*b*) 4.0 (*c*) 1.8 (*d*) 0.81.

24. A gas at p_1 (ab) from a vessel is discharged adiabatically through a converging nozzle into the other vessel where the pressure is p_2 (ab) with critical flow condition in the nozzle exit. If p_2 is maintained constant and p_1 is doubled, the mass flow rate through the nozzle will

(*a*) Not change (*b*) Be doubled

(*c*) Be halved (*d*) Increases by $\sqrt{2}$ times.

ANSWERS

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

17.43. For a triangular cross-section canal, show that the cross-section is most efficient with sides make an angle of 45 with vertical. Prove that for such canal m (hydraulic radius = $\frac{A}{P}$) in this case is given by.

$$m = \frac{H}{2\sqrt{2}}$$

17.44. For a triangular cross-sectional canal, show that the cross-section becomes most efficient when sides make an angle 45° with the vertical. Find the hydraulic radius (m) in terms of depth of flow.

17.45. Water flows in a channel of the shape of isosceles triangle of bed width 'b' and sides make an angle 45° with the bed. Find the relation between depth of flow H and bed width b for maximum velocity condition and for maximum discharge condition. Use Manning formulae and note that $H < 0.5\,b$.

[**Ans.** For max . velocity $H = 0.338\,b$
For max discharge $H = 0.438\,b$.]

OBJECTIVE TYPE QUESTIONS

1. For the flow through open channel
   (*a*) The friction head loss is equal to the difference in elevation of the bed of the channel,
   (*b*) The free water surface is parallel to the bed of the channel,
   (*c*) The discharge through the channel at every section is same,
   (*d*) All of the above.
2. In a open channel H_1 and H_2 represents the depth of water at any two sections of the channel. The flow through the channel will be uniform if
   (*a*) $H_1 = H_2$, (*b*) $H_1 > H_2$, (*c*) $H_1 < H_2$, (*a*) None of the above.
3. The Chezy's formula for uniform discharge through an open channel is given by.
   $$Q = AC\sqrt{mi},$$
   where i represents
   (*a*) Hydraulic mean depth, (*b*) bed slope of the channel,
   (*c*) wetted perimeter, (*d*) None of the above.
4. The Chezy's formula for uniform flow. Through the channel is given by.
   (*a*) $Q = A\,m\sqrt{c.i}$, (*b*) $Q = A\,i\,\sqrt{m.c}$, (*c*) $Q = A\,C\,\sqrt{mi}$, (*d*) None of the above.
5. Manning formula is used for determining
   (*a*) Chezy's constant, (*b*) bed slope of channel,
   (*c*) Side slope of a trapezoidal channel, (*d*) Hydraulic mean depth of a circular channel.
6. In a rectangular channel if b is width and H is water depth for most economical section then
   (*a*) $b = 2H$, (*b*) $H = 2b$, (*c*) $b = \sqrt{\frac{H}{2}}$, (*d*) $H = \sqrt{\frac{b}{2}}$.
7. The hydraulic depth (m) of a trapezoidal channel for most economical cross-section is given by.
   (*a*) $\frac{2}{H}$, (*b*) $\frac{H}{2}$, (*c*) $\frac{3H}{2}$, (*d*) $\frac{2H}{3}$.
8. In a circular open channel, the required condition for maximum velocity through the channel is
   (*a*) $H = 2.734\,D$, (*b*) $H = 0.607\,D$, (*c*) $H = 4.5\,D$, (*d*) $H = 0.81\,D$.
   where H is depth of water and D is diameter of the channel.
9. The discharge through a circular open channel becomes maximum if it satisfies the condition
   (*a*) $m = 0.375\,R$, (*b*) $m = 0.537$, (*c*) $m = 0.573$, (*d*) $m = 0.735$.
   where m is hydraulic radius.

10. The Chezy's constant in terms of Manning constant is given by.

(a) $C = \frac{(m)^{\frac{1}{6}}}{N}$, (b) $C = \frac{(N)^{\frac{1}{6}}}{m}$, (c) $C = m\ (N)^{\frac{1}{6}}$, (d) $C = N(m)^{\frac{1}{6}}$.

11. For a hydraulically efficient triangular section, the hydraulic radius (m) is given by

(a) $m = 2\sqrt{2}\ H$, (b) $m = \frac{H}{2\sqrt{2}}$, (c) $m = \frac{H}{2}$, (d) $m = \sqrt{H}$.

12. For a hydraulically efficient rectangular channel of bed width 4 m, the depth of flow is

(a) 2, (b) $\frac{1}{2}$, (c) 4, (d) $\sqrt{2}$.

13. A hydraulically efficient trapezodial section having side slopes 2 horizontal to 1 vertical the ratio of bed width to depth $\left(\frac{b}{H}\right)$ is given by

(a) 0.427, (b) 0.247, (c) 0.724, (d) 0.472.

14. In a hydraulically efficient circular channel the ratio of hydraulic radius to the diameter of the channel $\left(\frac{m}{D}\right)$ is

(a) 1.0, (b) 0.75, (c) 0.5, (d) 0.25.

15. In a hydydraulically **most efficient** trapezoidal channel, the ratio of bed width to depth is

(a) 15.55, (b) 1.555, (c) 155.5, (d) 0.5.

16. Two triangular channels A and B have same bed slope, roughness (ε) and depth of flow. The side slope of A is 1 : 1 where as for B it is 2 horizontal 1 vertical. The ratio of discharge (Q_a/Q_b) is

(a) 4.27, (b) 7.42, (c) 2.74, (d) 0.427.

17. The discharge through the rectangular channel becomes maximum when

(a) $m = \frac{H}{3}$, (b) $m = \frac{H}{2}$, (c) $m = 2H$, (d) $m = 1.5H$.

where m is hydraulic radius and H is depth of flow.

18. The discharge through a trapezoidal channel is maximum when

(a) Top . width = Sloping side, (b) Top width = 2 × Sloping side,
(c) Top width = 1.5 × sloping side, (d) None of the above.

19. For a circular channel, the area of flow is given by

(a) $R^2(\theta - \sin\theta)$, (b) $R^2\left(\theta - \frac{\sin 2\theta}{2}\right)$, (c) $R^2\left(2\theta - \frac{\sin 2\theta}{2}\right)$, (d) $R^2\left(\frac{\theta}{2} - \sin 2\theta\right)$.

where 2θ is angle subtended by the water surface at the centre and R is radius of circular channel.

20. For a circular channel, the wetted perimeter is given by.

(a) $R\theta$, (b) $2R\theta$, (c) $\frac{R\theta}{2}$, (d) $3R\theta$.

ANSWERS

1. (d)	2. (a)	3. (b)	4. (c)	5. (a)
6. (a)	7. (b)	8. (d)	9. (c)	10. (a)
11. (b)	12. (a)	13. (d)	14. (d)	15. (b)
16. (d)	17. (b)	18. (a)	19. (b)	20. (b).

18.33. Find the slope of free water surface in an open-channel of 15 m wide and having a depth of flow 4 m. The discharge is 40 m^3/s. The bed slope of the channel is 2.5×10^{-4}.
Take C (Chezy's constant) = 60.

18.34. Find out the length of back water curve caused by an affux of 1.5 m in a rectangular channel of 50 m wide and 2 m deep.
Take channel bed slope = 5×10^{-4} and Manning constant (N) = 0.03

OBJECTIVE QUSTIONS

(A) SPECIFIC ENERGY

1. The specific energy of a liquid is the
   (*a*) Energy per unit weight of liquid, (*b*) Energy per unit mass of liquid,
   (*c*) Energy due to motion of liquid, (*d*) None of the above.
2. The specific energy of the liquid is
   (*a*) The Summation of potential and kinetic energy,
   (*b*) The summation of pressure energy and potential energy,
   (*c*) The summation of pressure energy and kinetic energy,
   (*d*) None of the above.
3. Specific energy curve indicates
   (*a*) Depth of flow *Vs* kinetic energy, (*b*) Depth of flow *Vs* potential energy,
   (*c*) Depth of flow *Vs* (potential + kinetic) energy, (*d*) None of the above.
4. For the same specific energy
   (*a*) There can be one depth of flow, (*b*) There can be two depths of flow,
   (*c*) There can be three depths of flow, (*d*) There can be '*n*' depths of flow.
5. Specific energy of a flowing liquid through an open channel is
   (*a*) Constant at any section, (*b*) Different at different sections,
   (*c*) Average of (*a*) and (*b*), (*d*) None of the above.
6. The specific energy of a flowing fluid per unit weight is
   (*a*) $\frac{p}{w} + \frac{v^2}{2g}$, (*b*) $\frac{p}{w} + h$, (*c*) $\frac{v^2}{2g} + h$, (*d*) $\frac{p}{w} + \frac{v^2}{2g} + Z$.
7. If h_c is critical depth and v_c is critical velocity then they are related with each other by.
   (*a*) $v_c = \sqrt{gh_c}$, (*b*) $v_c = gh_c$, (*c*) $v_c = \sqrt{2gh_c}$, (*d*) $v_c = gh_c^2$.
8. If h_c is critical head and E_{min} is minimum specific energy then they are related with each other by.
   (*a*) $h_c = \frac{3}{2} E_{min}$, (*b*) $h_c = \frac{2}{3} E_{min}$, (*c*) $h_c = \frac{3}{4} E_{min}$, (*d*) $h_c = \frac{4}{3} E_{min}$.
9. If h_c is critical depth and q is discharge per unit width of the channel then they are related with each other by.
   (*a*) $h_c^3 = \frac{q^2}{g}$, (*b*) $h_c^3 = \frac{q^2}{2g}$, (*c*) $h_c^3 = \frac{2g}{q^2}$, (*d*) $h_c^3 = \frac{g}{q^2}$.

(B) HYDRAULIC JUMPS

10. The term alternate depths in open chanel flow is used to designate the depths.
    (*a*) At the beginning and end of hydraulic jump,
    (*b*) Having the same kinetic energy for a given discharge,
    (*c*) Having the same specific energy for the given discharge,
    (*d*) At the beginning and end of a gradually varied flow profile.

11. If two alternative depths in wide rectangular channel are 2 m and 3.1 m the discharge q ($m^3/m/s$) is
(*a*) 12.61, (*b*) 12.16, (*c*) 21.16, (*d*)16.12.
12. The alternate depths at a section in a rectangular channel are 40 cm and 160 cm. The specific energy at that section is
(*a*) 6.18 m, (*b*) 8.16, (*c*) 1.68, (*d*)1.86.
13. The alternate depths for a certain flow in a rectangular channel are 0.5 m and 3 m, the critical depth of the channel is
(*a*) 1.807 m, (*b*) 1.708 m, (*c*) 1.333 m, (*b*)1.087 m.
14. For a triangular channel having side slopes 2 (horizontal) : 1 vertical, the froud No. is given by
(*a*) $\frac{v}{\sqrt{gy}}$, (*b*) $\frac{v}{\sqrt{\frac{gy}{2}}}$, (*c*) $\frac{2v}{\sqrt{gy}}$, (*d*)$\frac{v}{\sqrt{2gy}}$.
15. In a rectangular channel, if the critical depth is 2 m, the specific enrgy at critical depth is
(*a*) 2 m, (*b*) 3 m,
(*c*) 4 m, (*d*) 2.5 m.
16. The specific energy in a rectangular channel having a depth of 0.6 m and froud No. 2 when the flow is uniform is
(*a*) 1.8 m, (*b*) 8.1 m, (*c*) 0.18 m, (*d*)0.81 m.
17. A rectangular channel of 4 m width carries water at 8 m^3/s under critical condition. The specific energy for this flow is
(*a*) 0.758 m, (*b*) 0.378 m, (*c*) 1.112 m, (*d*)1.516 m.
18. A triangular channel with side slopes of 3 horizontal : 2 vertical carries 2 m^3/s. The critical depth for this flow is
(*a*) 0.816 m, (*b*) 1.632 m, (*c*) 0.408 m, (*d*)0.742 m.
19. In a triangular channel with side slope 2 horizontal : 1 vertical, the critical depth is 2.8 m. The specific energy at the critical depth is
(*a*) 3.5 m, (*b*) 5.3 m, (*c*) 4.2 m, (*b*)2.4 m.
20. A triangular channel with side slopes 3 horizontal : 2 vertical carries a flow at a critical state with specific energy of 2.5 m. The discharge (m^3/s) passing through the channel is
(*a*) 5.96, (*b*) 9.65, (*a*) 18.79, (*b*)79.18.
21. For the given discharge in a channel at critical depth
(*a*) The total energy is minimum, (*b*) The specific energy is minimum,
(*c*) The total energy is maximum, (*d*) The specific energy is maximum.
22. For the given discharge in a channel, the critical depth is a fuction of
(*a*) Slope of the channel, (*b*) Roughness of the channel,
(*c*) Geometry of the channel, (*d*) Properties of liquid flowing through the channel.
23. During hydraulic jump
(*a*) The energy increases, (*b*) The energy decreases,
(*c*) The energy remains constant, (*d*) The energy first decreases and then increases.
24. After the hydraulic jump
(*a*) The velocity of water increases, (*b*) Velcity of water decreases,
(*c*) The velocity of water remains constant,
(*d*) The velocity first increases then decreases.
25. Hydraulic jump occurs in the
(*a*) Upstream side of the dam, (*b*) Downstream side of the dam,
(*c*) Top surface of the dam, (*d*) All the above.

26. The sequent depth ratio of a hydraulic jump in a rectangular channel is 16.48. The Froud No. before the jump is

(*a*) 5, (*b*) 12, (*c*) 0.5, (*d*) 1.2.

27. The Froud No. at the end of hydraulic jump in a rectangular channel is 0.25. The depth ratio (h_2/h_1) of this jump is

(*a*) 8.9, (*b*) 8.9, (*c*) 2.5, (*d*) 5.2.

28. The sequent depthis formed in a hydraulic jump in a 4 m wide rectangular channel are 20 cm and 100 cm. The discharge (m³/s) in the channel is

(*a*) 3.44, (*b*) 4.33, (*c*) 4.34, (*d*) 2.52.

29. The sequent depths during the hydraulic jump occuring in a rectangular channel are 0.25 m and 1.25 m. The energy loss in the jump is

(*a*) 0.8 m, (*b*) 8.0 m, (*c*) 0.25, (*d*) 1.25.

30. The depth of flow (h_2) after hydraulic jump is

(*a*) $\frac{h_1}{2}\left[\sqrt{1+8F_1^{21}}-1\right]$, (*b*) $\frac{h_1}{2}\left[\sqrt{8F_1^2-1}\right]$,

(c) $\frac{h_1}{2}+\sqrt{\frac{h_1^2}{4}+8F_1}$, (*d*) None of the above.

31. In open channel flow

(*a*) The energy grade line coincides with free surface,

(*b*) The energy grade line coincides with hydraulic grade line,

(*c*) The hydraulic grade line and free surface coincide,

(*d*) None of the above.

32. The critical depth in a channel is expressed by

(*a*) $\frac{Q^2T}{gA^3}=1$, (*b*) $\frac{QT^2}{gA^2}=1$, (*c*) $\frac{QT^2}{gA^3}=1$, (*d*) $\frac{Q^2A^3}{gT^2}=1$.

33. Hydraulic jump is used for

(*a*) Increasing the depth of flow, (*b*) Reducing the energy of flow,

(c) Decreasing the velocity of flow, (*d*) All the above.

ANSWERS

1. (*a*)	**2.** (*a*)	**3.** (c)	**4.** (*b*)	**5.** (*b*)
6. (c)	**7.** (*a*)	**8.** (*b*)	**9.** (*a*)	**10.** (c)
11. (*b*)	**12.** (c)	**13.** (*d*)	**14.** (*b*)	**15.** (*b*)
16. (*a*)	**17.** (c)	**18.** (*a*)	**19.** (*a*)	**20.** (c)
21. (*b*)	**22.** (c)	**23.** (*b*)	**24.** (*b*)	**25.** (*b*)
26. (*b*)	**27.** (*a*)	**28.** (c)	**29.** (*a*)	**30.** (*a*)
31. (c)	**32.** (*a*)	**33.** (*d*)		