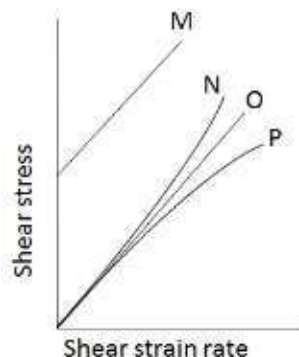


XE (B): Q. 1 – Q. 9 carry one mark each & Q. 10 – Q. 22 carry two marks each.

- Q.1 Rheological diagram of different types of fluids is shown in figure. Column I represents the nature of the fluid and column II represents the curve showing the variation of shear stress against shear strain rate.

Column I	Column II
(i) Newtonian	M
(ii) Shear thinning	N
(iii) Shear thickening	O
(iv) Bingham plastic	P



The most appropriate match between columns I and II is,

- (A) (i) – O; (ii) – N; (iii) – P; (iv) – M
 (B) (i) – O; (ii) – P; (iii) – N; (iv) – M
 (C) (i) – P; (ii) – O; (iii) – M; (iv) – N
 (D) (i) – P; (ii) – O; (iii) – N; (iv) – M

- Q.2 In a two-dimensional, incompressible and irrotational flow, stream function ($\psi = \psi(x, y)$) and velocity potential ($\phi = \phi(x, y)$) exist. The velocities in x and y directions are non-zero.

The product of $\frac{dy}{dx}\bigg|_{\phi=\text{constant}}$ and $\frac{dy}{dx}\bigg|_{\psi=\text{constant}}$, is

- (A) -1 (B) 0 (C) 1 (D) ∞

- Q.3 The inviscid flow past a rotating circular cylinder can be generated by the superposition of

- (A) uniform flow, source and vortex (B) uniform flow, doublet
 (C) uniform flow, sink and vortex (D) uniform flow, doublet and vortex

- Q.4 The velocity field and the surface normal vector are given by, $\vec{V} = u\hat{i} + v\hat{j} + w\hat{k}$ and $\vec{n} = n_1\hat{i} + n_2\hat{j} + n_3\hat{k}$, respectively. If Euler equations are to be solved, the boundary condition that must be satisfied at the wall is,

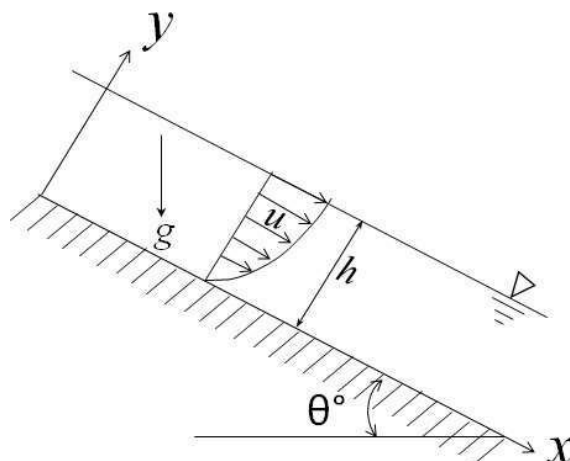
- (A) $\vec{V} \cdot \vec{n} = 0$ (B) $\vec{V} = 0$ (C) $\nabla \cdot \vec{V} = 0$ (D) $\vec{V} \times \vec{n} = 0$

- Q.5 The influence of Froude number is most significant in

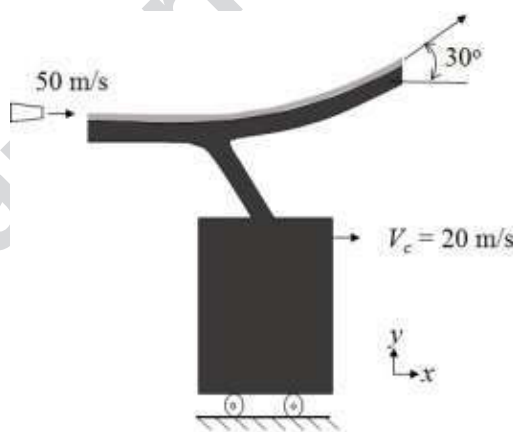
- (A) capillary flows (B) creeping flows
 (C) free surface flows (D) compressible flows

- Q.6 If the stream function ($\psi(x, y)$) for a two-dimensional incompressible flow field is given as $2y(x^2 - y^2)$, the corresponding velocity field is
- (A) $\vec{V} = 2(x^2 - 3y^2)\hat{i} + 4xy\hat{j}$
 (B) $\vec{V} = 2(x^2 - 3y^2)\hat{i} - 4xy\hat{j}$
 (C) $\vec{V} = 2(x^2y)\hat{i} - 4xy\hat{j}$
 (D) $\vec{V} = 2(x^2y)\hat{i} + 4xy\hat{j}$
- Q.7 Water is flowing in two different tubes of diameters D and $2D$, with the same velocity. The ratio of laminar friction factors for the larger diameter tube to the smaller diameter tube is
- (A) 0.5 (B) 1.0 (C) 2.0 (D) 4.0
- Q.8 If the velocity field is $\vec{V} = xy^2\hat{i} + 4xy\hat{j}$ m/s, vorticity of the fluid element in the field at $(x=1, y=2)$ in s^{-1} is ____.
- Q.9 A pitot-static tube is used to measure air velocity in a duct by neglecting losses. The density of air is 1.2 kg/m^3 . If the difference between the total and static pressures is 1 kPa , the velocity of air at the measuring location, in m/s, is ____.
- Q.10 A parallelepiped of $(2 \text{ m} \times 2 \text{ m})$ square cross-section and 10 m in length, is partially floating in water upto a depth of 1.2 m , with its longest side being horizontal. The specific gravity of the block is
- (A) 0.8 (B) 0.6 (C) 0.5 (D) 0.4
- Q.11 The velocity field in a two-dimensional, unsteady flow is given by $\vec{V}(x, y, t) = 2xy^2\hat{i} + 3xyt\hat{j}$ m/s. The magnitude of acceleration of a fluid particle located at $x = 1 \text{ m}$, $y = 1 \text{ m}$ at the time $t = 1 \text{ s}$, in m/s^2 , is
- (A) 16.0 (B) 18.1 (C) 24.1 (D) 34.1
- Q.12 In a two-dimensional, incompressible and irrotational flow, fluid velocity (v) in the y -direction is given by $v = 2x - 5y$. The velocity (u) in the x -direction is
- (A) $u = 2x - 5y$ (B) $u = 2x + 5y$ (C) $u = 5x + 2y$ (D) $u = 5x - 2y$

- Q.13 A two-dimensional laminar viscous liquid film of constant thickness (h) steadily flows down an incline as shown in figure. Acceleration due to gravity is g . If the velocity profile in the liquid film is given as, $u = ky(2h - y)$; $v = 0$, the value of constant k is



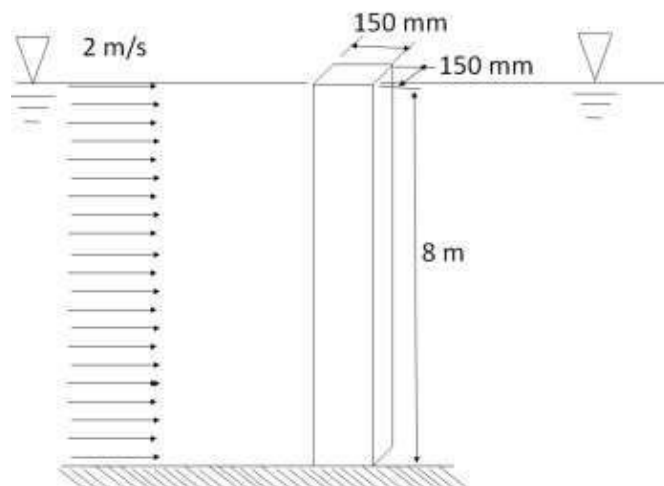
- (A) $\frac{\rho g \sin \theta}{2\mu}$ (B) $\frac{\rho g \cos \theta}{2\mu}$
(C) $\rho g \sin \theta$ (D) $\rho g \cos \theta$
- Q.14 A water jet of 100 mm diameter issuing out of a nozzle at a speed of 50 m/s strikes a vane and flows along it as shown in figure. The vane is attached to a cart which is moving at a constant speed of 20 m/s on a frictionless track. The jet is deflected at an angle of 30° . Take the density of water as 1000 kg/m^3 . Neglecting the friction between the vane and the fluid, the magnitude of the force exerted by water on the cart in the x-direction, in N, is _____.



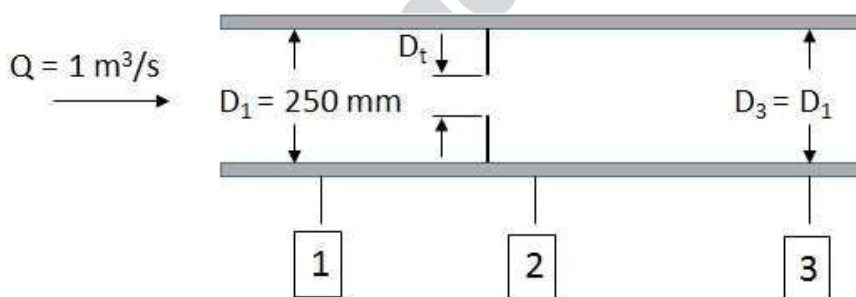
- Q.15 Capillary waves are generated in the sea. The speed of propagation (C) of these waves is known to be a function of density (ρ), wave length (λ), and surface tension (σ). Assume, ρ and λ to be constant. If the surface tension is doubled, in the functional form of the relevant non-dimensional group, the percentage increase in propagation speed (C) is _____.

- Q.16 Consider a fully developed, two-dimensional and steady flow of a viscous fluid between two fixed parallel plates separated by a distance of 30 mm. The dynamic viscosity of the fluid is 0.01 kg/m-s and the pressure drop per unit length is 300 Pa/m. The fluid velocity at a distance of 10 mm from the bottom plate, in m/s, is _____.
- Q.17 A 2.6 gram smooth table-tennis (ping-pong) ball has a diameter of 38 mm. Density (ρ) of air is 1.2 kg/m³. Neglect the effect of gravity. Take coefficient of drag as 0.5. If the ball is struck with an initial velocity of 30 m/s, the initial deceleration, in m/s², is _____.
- Q.18 On a flat plate, transition from laminar to turbulent boundary layer occurred at a critical Reynolds number (Re_{cr}). The empirical relations for the laminar and turbulent boundary layer thickness are given by $\frac{\delta_{lam}}{x} = 5.48 Re_x^{-0.5}$ and $\frac{\delta_{turb}}{x} = 0.37 Re_x^{-0.2}$, respectively. The ratio of laminar to turbulent boundary layer thickness, at the location of transition, is 0.3. The value of Re_{cr} is _____.
- Q.19 In a capillary tube of radius $R = 0.25$ mm, a fully developed laminar velocity profile is defined as, $u = \frac{R^2}{4\mu} \left(-\frac{dp}{dx} \right) \left(1 - \frac{r^2}{R^2} \right)$. In this expression, $-\frac{dp}{dx} = 1$ MPa/m, μ is the dynamic viscosity of the fluid, and r is the radial position from the centerline of the tube. If the flow rate through the tube is 1000 mm³/s, the viscosity of the fluid, in Pa-s, is _____.
- Q.20 The skin friction coefficient for a turbulent pipe flow is defined as, $C_f = \frac{\tau_w}{1/2 \rho V^2}$, where τ_w is the wall shear stress and V is the average flow velocity. The value of C_f is empirically given by the relation: $C_f = 0.065 \left(\frac{2}{Re} \right)^{0.25}$, where Re is the Reynolds number. If the average flow velocity is 10 m/s, diameter of the pipe is 250 mm, kinematic viscosity of the fluid is 0.25×10^{-6} m²/s, and density of the fluid is 700 kg/m³, the skin friction drag induced by the flow over 1 m length of the pipe, in N, is _____.

- Q.21 A (150 mm × 150 mm) square pillar is located in a river with water flowing at a velocity of 2 m/s, as shown in figure. The height of the pillar in water is 8 m. Take density of water as 1000 kg/m³ and kinematic viscosity as 1×10^{-6} m²/s. The coefficient of drag of the pillar is 2.0. The drag force exerted by water on the pillar in N is _____.



- Q.22 An orifice plate is used to measure flow rate of air (density = 1.23 kg/m³) in a duct of 250 mm diameter as shown in figure. The volume flow rate is 1 m³/s. Flow at sections 1 and 3 is uniform and section 2 is located at vena contracta. The diameter ratio, D_t/D_1 , is 0.66. The flow area at vena contracta, $A_2 = 0.65A_t$, where A_t is area of the orifice. The pressure difference between locations 2 and 3 in N/m² is _____.



END OF THE QUESTION PAPER