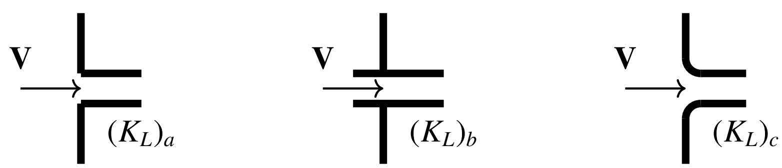
2024-ST-'53-65'

EE24BTECH11023

1) Which one of the following statements is TRUE about the continuity equation

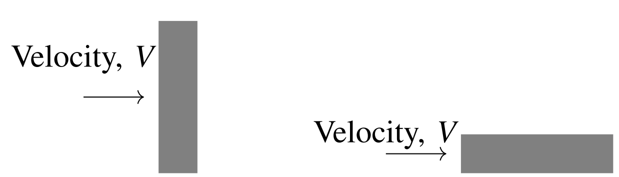
$$\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y} + \frac{\partial u}{\partial z}$$

(where u, v, w are the velocity components along the x, y, and z coordinates, respectively):
   a) The equation is valid only for steady incompressible flows.
   b) The equation is valid for both steady and unsteady incompressible flows.
   c) The equation is valid only for steady compressible flows.
   d) The equation is valid only for unsteady compressible flows.
2) The head loss (K_L) associated with the flow entry of water to an internal passage depends on the shape of the entry. The following figure shows three different types of flow entry into a pipe. Which one of the following relationships correctly represents the head loss associated with the three different flow entries?



(a) (b) (c)

   a) $(K_L)_a > (K_L)_b > (K_L)_c$
   b) $(K_L)_b > (K_L)_a > (K_L)_c$
   c) $(K_L)_b \leq (K_L)_a = (K_L)_c$
   d) $(K_L)_b < (K_L)_a < (K_L)_c$
3) The form and friction drags together contribute to the total drag when flow of air occurs past any object. Two orientations of a finite flat plate are shown in the figure. In Orientation-1, the plate is placed perpendicular to the flow, while in Orientation-2, the plate is placed parallel to the flow. If the velocity (V) of air in both orientations is the same, which one of the following options is TRUE?

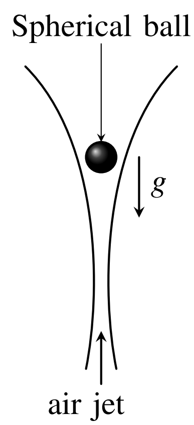


Orientation-1 Orientation-2

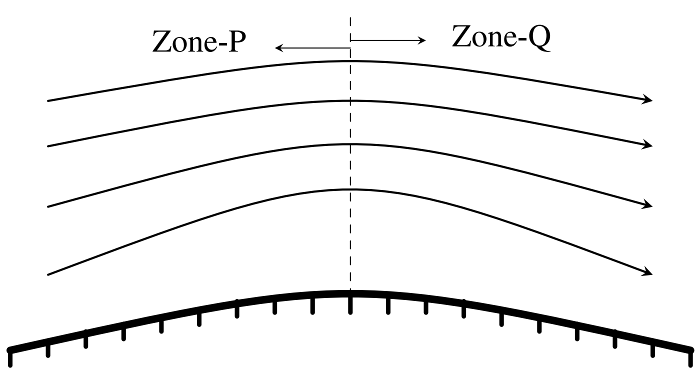
   a) Orientation-1 has higher form drag and lower friction drag, and Orientation-2 has lower form drag and higher friction drag.

b) Orientation-1 has lower form drag and lower friction drag, and Orientation-2 has higher form drag and higher friction drag.
c) Orientation-1 has lower form drag and higher friction drag, and Orientation-2 has higher form drag and lower friction drag.
d) Orientation-1 has higher form drag and higher friction drag, and Orientation-2 has lower form drag and lower friction drag.

4) A spherical ball is steadily supported against gravity by an upward air jet. Take acceleration due to gravity to be $g = 10\,\mathrm{m/s^2}$. The mass flow rate of air, reaching the ball, is 0.01 kg/s, and the air reaches the ball at an upward velocity of 3 m/s. Neglecting the buoyancy force, and using the principle of integral momentum balance, the mass (in grams, up to one decimal place) of the ball is __________.



5) The incompressible flow of air over a curved surface having possible flow separation is schematically shown in the figure. Two zones P and Q are indicated in the figure. Which one of the following combinations is TRUE for zones P and Q?

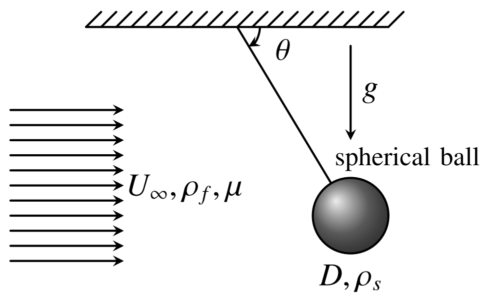


(a) Acceleration of flow,(b) Deceleration of flow,(c) Adverse pressure gradient,(d)Favorable pressure gradient,(e) No flow separation (f) Possible flow seperation.

a) P: (a), (d), (e) and Q: (b), (c), (f)
b) P: (a), (c), (e) and Q: (a), (d), (e)
c) P: (a), (d), (f) and Q: (b), (d), (e)
d) P: (a), (c), (e) and Q: (a), (f), (e)

6) A spherical metal ball (of density ρ_s and diameter D), attached to a string, is exposed to

a crossflow (of velocity U_∞) of a viscous fluid (of viscosity μ and density ρ_f). Due to the crossflow, the string makes an angle of inclination, θ, with the top surface as shown in the figure. The acceleration due to gravity is denoted by g. For this flow, Reynolds number, $\mathrm{Re} = \frac{\rho_f U_\infty D}{\mu} \ll 1$ and buoyancy force in the fluid is negligible compared to viscous force. Assuming the string to be weightless and offering negligible drag, derive the expression for θ is



a) $\tan^{-1}(\frac{1}{18}\frac{D^2 {\rho_s}^2 g}{U_\infty \mu \rho_f})$
b) $\tan^{-1}(\frac{1}{18}\frac{D^2 \rho_f g}{U_\infty \mu})$
c) $\tan^{-1}(\frac{2}{9}\frac{D^2 \rho_s g}{U_\infty \mu})$
d) $\tan^{-1}(\frac{1}{18}\frac{D^2 \rho_s g}{U_\infty \mu})$

7) In a Cartesian coordinate system, a steady, incompressible velocity field of a Newtonian fluid is given by

$$\mathbf{V} = u_0(1 - ay^2)\,\hat{i}$$

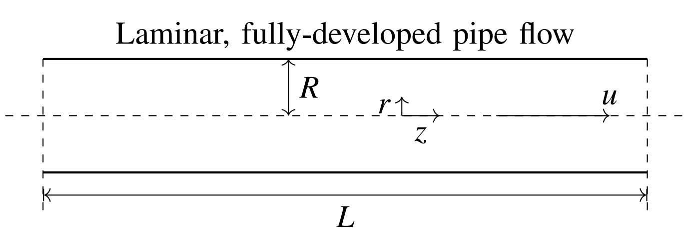
Here, V is the velocity vector in m/s, i is the unit vector in the x-direction,u_0 is a positive, real constant (in m/s), and a is a positive, real constant (in m^{-2}). The viscosity of the fluid is μ (in Pa·s). Determine the absolute value of the pressure gradient (in Pa/m) is

a) $a\mu u_0$
b) $2a\mu u_0$
c) $3a\mu u_0$
d) $4a\mu u_0$

8) In a laminar, incompressible, fully-developed pipe flow of a Newtonian fluid,as shown in the figure, the velocity profile over a cross-section is given by

$$v = U(1 - r^2/R^2)$$

where U is a constant. The pipe length is L and the fluid viscosity is μ. The power P required to sustain the flow is expressed as $P = c\mu L U^2$, where c is a dimensionless constant.The value of the constant c (up to one decimal place) is __________.

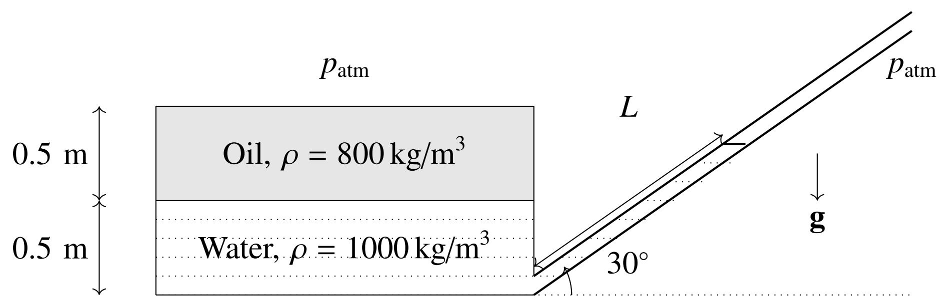


9) The two-dimensional velocity field $\mathbf{V}$ of a flow in a Cartesian coordinate system is given in dimensionless form by

$$\mathbf{V} = (x^2 - axy)\,\hat{\imath} + (bxy - \frac{y^2}{2})\,\hat{\jmath}$$

Here, i and j are the unit vectors along the x and y directions respectively, a and b are independent of x,y and time. If the flow is incompressible,then the value of $(a - b)$, up to one decimal place is __________.

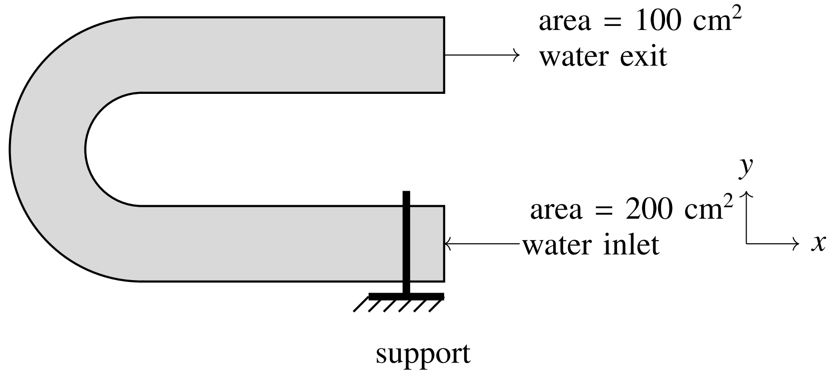
10) For the configuration shown in the figure, oil of density $800\,\mathrm{kg/m^3}$ lies above water of density $1000\,\mathrm{kg/m^3}$. Assuming hydrostatic conditions and acceleration due to gravity $g = 10\,\mathrm{m/s^2}$, the length L (in meters, up to one decimal place) of water in the inclined tube __________.



11) A two-dimensional Eulerian velocity field is given (in m/s) by $\mathbf{V} = \left(\sqrt{5}x\right)\hat{\imath} - \left(\sqrt{12}y\right)\hat{\jmath}$, where x and y are the coordinates (in meters) in a Cartesian coordinate system.The magnitude of the acceleration (in $\mathrm{m/s^2}$, up to one decimal place) of a fluid particle at $x = 1\,\mathrm{m}$ and $y = -1\,\mathrm{m}$ is __________.

12) A large pump is to deliver oil at an average velocity V of $1.5m/s$. The pump has an impeller diameter (D) of 40cm and the pressure rise across the pump is $400kPa$. To design this pump, a lab-scale model pump with an impeller diameter of $4cm$ is to be used with water as the fluid. The viscosity (μ) of the oil is 100 times that of water, and the densities (ρ) of oil and water are identical. A complete geometric similarity is maintained between the model and prototype. If the pressure rise is a function only of V, D, ρ, and μ, the pressure rise (in kPa, up to one decimal place) across the model pump is __________.

13) Water (density = $1000\mathrm{kg/m^3}$) enters steadily into a horizontal pipe bend, which is part of a larger piping system, as shown in the figure. The volumetric flow rate of water is $0.1\,\mathrm{m^3/s}$. The gage pressure at the inlet is 500kPa, while the exit is open to the atmosphere. The x-component of the force on the support F_x.The absolute value of F_x(in kN, up to one decimal place) is __________.


area = 100 cm^2
water exit
area = 200 cm^2
water inlet
y
x
support