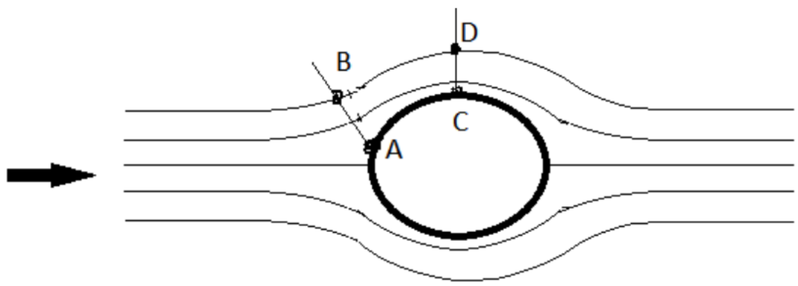
XE-2016

EE24Btech11022 - Eshan Sharma

1) The flow field shown over a bluff body has considerably curved streamlines. A student measures pressures at points A, B, C, and D and denotes them as P_A, P_B, P_C, and P_D respectively. State which one of the following statements is true. The arrow indicates the freestream flow direction.



a) $P_A = P_B$ and $P_C > P_D$
b) $P_A > P_B$ and $P_C > P_D$
c) $P_A = P_B$ and $P_C < P_D$
d) $P_A > P_B$ and $P_C < P_D$

2) A 2-D incompressible flow is defined by its velocity components in m/s as $u = -\frac{cy}{x^2+y^2}$ and $v = \frac{cx}{x^2+y^2}$. If the value of the constant c is equal to 0.1 m^3, the numerical value of vorticity at the point $x = 1$ m and $y = 2$ m is _____ s^{-1}.

3) Two flow configurations are shown below for flow of incompressible, viscous flow. The inlet velocity for the diverging nozzle (Fig (i)) and free-stream velocity for flow past the bluff body (Fig (ii)) is constant. Points A and B are separation points and flow is laminar. The relation regarding velocity gradients at point A and B is (y is the direction normal to the surface at the point of separation).

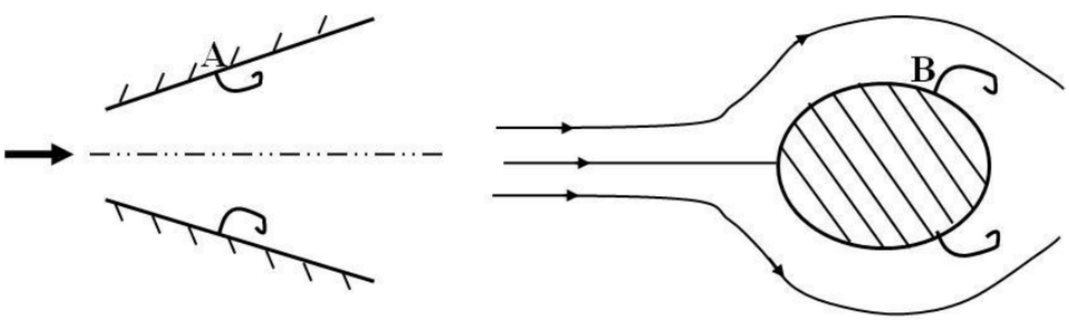
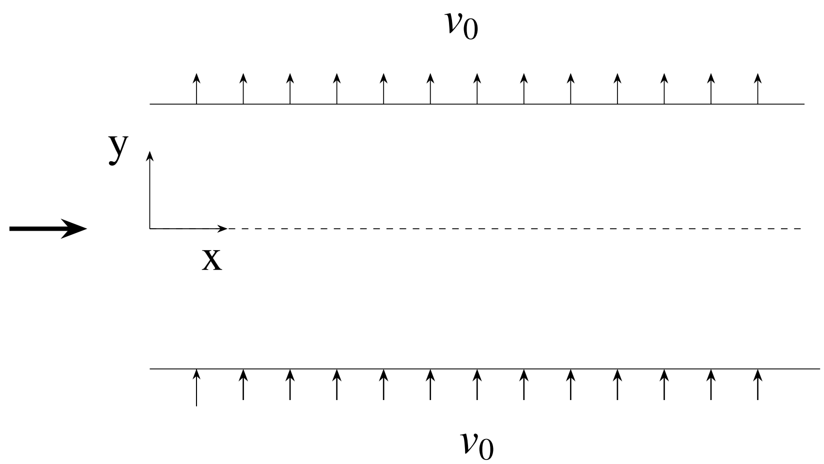


Fig (i) Fig (ii)

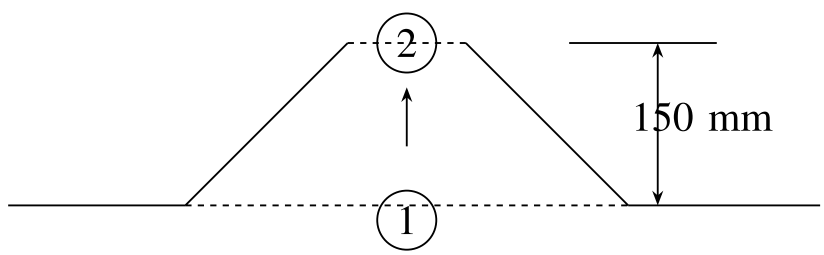
a) $\left.\frac{\partial u}{\partial y}\right|_A = \left.\frac{\partial u}{\partial y}\right|_B$ b) $\left.\frac{\partial u}{\partial y}\right|_A > \left.\frac{\partial u}{\partial y}\right|_B$ c) $\left.\frac{\partial u}{\partial y}\right|_A < \left.\frac{\partial u}{\partial y}\right|_B$ d) $\left.\frac{\partial^2 u}{\partial y^2}\right|_A = \left.\frac{\partial^2 u}{\partial y^2}\right|_B$

4) Consider a fully developed, steady, incompressible, 2-D, viscous channel flow with uniform suction and blowing velocity v_0 as shown in the figure below. The centerline velocity of the channel is 10

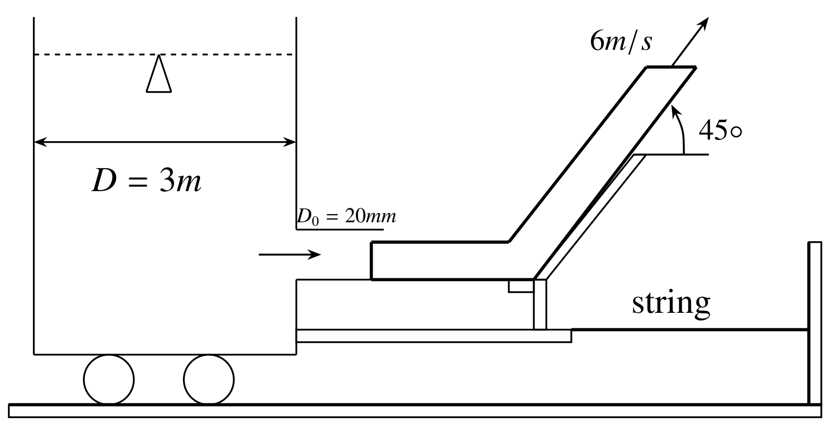
m/s along the x-direction. If the value of v_0 at both the walls is 1 m/s, the value of the y-component of velocity inside the flow field is _ _ _ _ _ m/s.



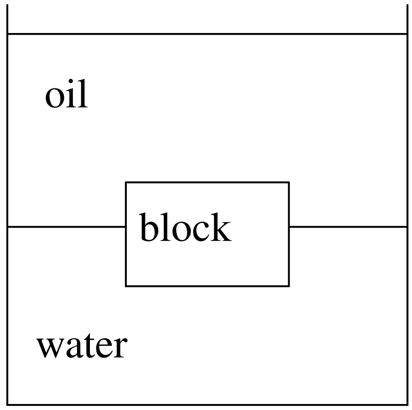
5) Exhaust from a kitchen goes into the atmosphere through a tapered chimney as shown. The area of cross-section of a chimney at location-1 is twice of that at location-2. The flow rate is assumed to be steady with constant exhaust density of 1 kg/m^3 and acceleration due to gravity, g = 9.8 m/s^2. If the steady uniform exhaust velocity at location-1 is U = 1 m/s, the pressure drop across the chimney is _ _ _ _ Pa.



6) A jet of diameter 20 mm and velocity 6 m/s coming out of a water-tank standing on a frictionless cart hits a vane and gets deflected at an angle of 45° as shown in the figure below. The density of water is 1000 kg/m^3. Neglect all minor and viscous losses. If the cart remains stationary, the magnitude of tension in the supporting string connected to the wall is _ _ _ _ N.



7) A block is floating at the oil-water interface as shown. The density of oil is two-thirds that of water. Given that the density of the block is 800 kg/m^3 and that of water is 1000 kg/m^3, the fraction of the total height of block in oil is ____.

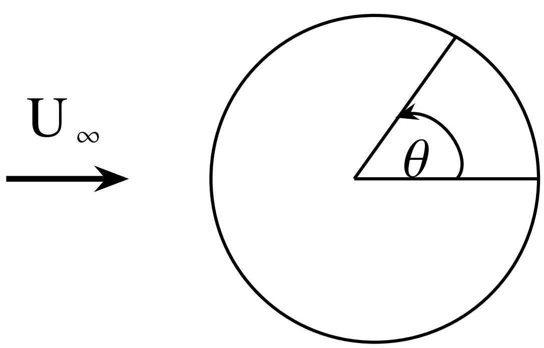


8) A horizontal pipe is feeding water into a reservoir from the top with a time-dependent volumetric flow rate, $\mathbf{Q}\left(m^3/h\right) = 1 + 0.1 \times t$, where t is in hours. The area of the base of the reservoir is $0.5m^2$. Assuming that initially the reservoir is empty, the height of the water level in the reservoir after 60 minutes is ____ m.

9) Velocity field of a 2-D steady flow is provided as $\mathbf{V} = c\left(x^2 - y^2\right)\hat{\imath} - 2cxy\hat{\jmath}$. The equation of streamlines of this flow is:

a) $x^2y - \frac{y^2}{3} = \text{Constant}$
b) $xy^2 - \frac{y^2}{3} = \text{Constant}$
c) $xy - \frac{y}{3} = \text{Constant}$
d) $x^2y - \frac{y^3}{3} = \text{Constant}$

10) Velocity potential and stream function in polar coordinates (r, θ) for a potential flow over a cylinder with radius R is given as $\phi = U_\infty\left(r + \frac{R^2}{r}\right)\cos\theta$ and $\psi = U_\infty\left(r - \frac{R^2}{r}\right)\sin\theta$, respectively. Here, U_∞ denotes uniform freestream velocity, and θ is measured counter clockwise as shown in the figure. How does the velocity magnitude, $\mathbf{q}$, over the surface of the cylinder will vary?



a) $\mathbf{q} = 2U_\infty \cos\theta$
b) $\mathbf{q} = U_\infty \cos 2\theta$
c) $\mathbf{q} = 2U_\infty \sin 2\theta$
d) $\mathbf{q} = 2U_\infty \sin\theta$

11) Consider a laminar flow of water over a flat plate of length $L = 1$ m. The boundary layer thickness at the end of the plate is δ_w for water, and δ_a for air for the same freestream velocity. If the kinematic viscosities of water and air are 1×10^{-6} m^2/s and 1.6×10^{-5} m^2/s, respectively, the numerical value

of the ratio $\frac{\delta_w}{\delta_a}$ is _____.

12) Prototype of a dam spillway (a structure used for controlled release of water from the dam) has characteristic length of 20 m and characteristic velocity of 2 m/s. A small model is constructed by keeping Froude number same for dynamic similarity between the prototype and the model. What is the minimum length-scale ratio between prototype and the model such that the minimum Reynolds' number for the model is 100? The density of water is 1000 kg/m^3 and viscosity is 10^{-3} Pa·s.

a) 1.8×10^{-4} b) 1×10^{-4} c) 1.8×10^{-3} d) 9.1×10^{-4}

13) An orifice meter, having orifice diameter of $d = \frac{20}{\sqrt{\pi}}$ mm, is placed in a water pipeline having flow rate, $Q_{\text{act}} = 3 \times 10^{-4}$ m^3/s. The ratio of orifice diameter to pipe diameter is 0.6. The contraction coefficient is also 0.6. The density of water is 1000 kg/m^3. If the pressure drop across the orifice plate is 43.5 kPa, the discharge coefficient of the orifice meter at this flow Reynolds number is ________.