GATE 2022 XE(27-39)

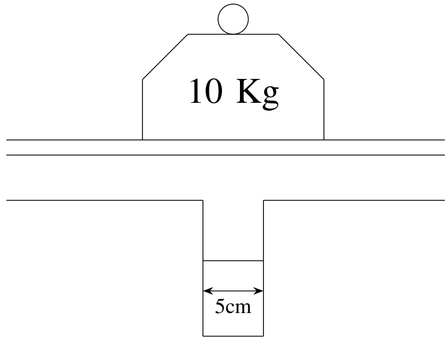
EE24BTECH11030 - J.KEDARANANDA

1) Which of the following statement(s) is/are true for streamlines in a steady incompressible flow?
   a) Two streamlines cannot intersect each other.
   b) Flow rate increases between two diverging streamlines.
   c) Flow rate decreases between two diverging streamlines.
   d) Stream function has a constant value along a streamline.

2) A flow has a velocity potential given by $\Phi = Ax^3$ where A is a non-zero constant. Which of the following statement(s) is/are true about the flow?
   a) The flow is incompressible.
   b) The flow is irrotational.
   c) The flow has local acceleration.
   d) The flow has convective acceleration.

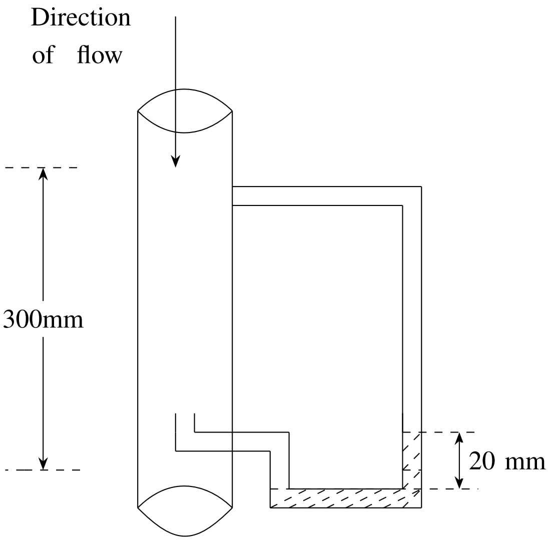
3) A boundary layer develops due to a two-dimensional steady flow over a horizontal flat plate. Consider a vertical line away from the leading edge which extends from the wall to the edge of the boundary layer. Which of the following quantity/quantities is/are not constant along the vertical line? u and v represent the components of velocity in the direction along the plate and normal to it, respectively, and x is taken along the length of the plate while p is the pressure. Neglect body forces.
   a) u
   b) $\frac{\partial u}{\partial x}$
   c) v
   d) p

4) A 10 kg mass placed on an infinitely long horizontal massless flat platform is to be supported by a steady vertical water jet as shown in the figure. The diameter of the jet is 5 cm. What minimum average velocity is required to hold the mass in place?



Assume $\rho_{\text{water}} = 1000$ kg/m^3, $g = 10$ m/s^2 and $\pi = 3.14$. Neglect friction. ______ (Round off to two decimal places.)

5) Consider an inviscid flow through a smooth pipe which has a pitot-static tube arrangement as shown. Find the centre-line velocity in the pipe.
Consider that the density of the fluid is 1000 kg/m^3, acceleration due to gravity is 10 m/s^2, and the specific gravity of the manometric fluid is 11.



a) 2 m/s
b) 3 m/s
c) 5 m/s
d) 7 m/s

6) The speed of propagation, c, of a capillary wave depends on the density of the fluid, ρ, the wavelength of the wave, λ, and the surface tension, σ. If the density

and wavelength remain constant, halving the surface tension would lead to a new velocity, c', given by

a) $c' = \sqrt{2}c$
b) $c' = \frac{c}{\sqrt{2}}$
c) $c' = \frac{c}{2}$
d) $c' = 2c$

7) A two-dimensional flow field is described by a combination of a source of strength m at the origin and a uniform flow, U, in the positive x-direction such that the velocity potential is given by

$$\phi = Ux + \frac{m}{2\pi} \ln \sqrt{x^2 + y^2}$$

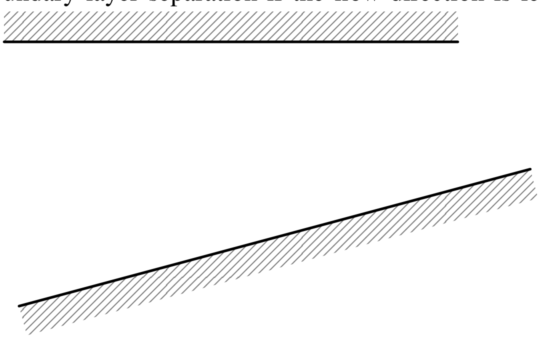
The stagnation streamline is shown in the figure. Find the distance a'.

a) $\frac{m}{U}$
b) $\frac{2m}{U}$
c) $\frac{8m}{U}$
d) $\frac{m}{2U}$

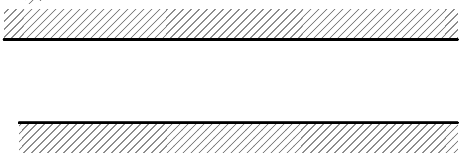
8) A typical boundary layer over a flat plate has a linear velocity profile with zero velocity at the wall and freestream velocity, U_∞, at the outer edge of the boundary layer. What is the ratio of the momentum thickness to the thickness of the boundary layer?

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

9) Identify the configuration(s) in which steady two-dimensional internal flow may show boundary layer separation if the flow direction is left to right.



a)



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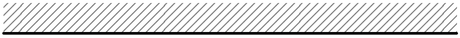
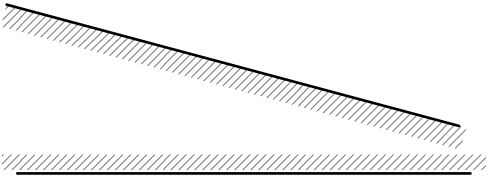
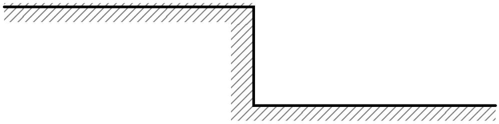


c) 

d) 

10) Consider steady fully developed flow of a liquid through two large horizontal flat parallel plates separated by a distance of 2 mm. One of the plates is fixed and the other plate moves at a speed of 0.5 m/s. What is the magnitude of the pressure gradient (in Pa/m) in the direction of the flow required to ensure that the net flow through the plates is zero?
Dynamic viscosity of the liquid is 5×10^{-4} Ns/m^2
(Round off to the nearest integer)

11) Consider two-dimensional turbulent flow of air over a horizontal flat plate of length 1 m. Skin friction coefficient at a length x from the leading edge of the plate is obtained as:

$$c_f = \frac{0.06}{(Re_x)^{0.2}}$$

where, Re_x is the local Reynolds number.
Find out the drag force per unit width (in N/m^2) on the plate if the free stream air velocity is 10 m/s.
Density and dynamic viscosity of air are given as 1.2 kg/m^3 and 1.83×10^{-5} Ns/m^2, respectively.
(Round off to three decimal places)

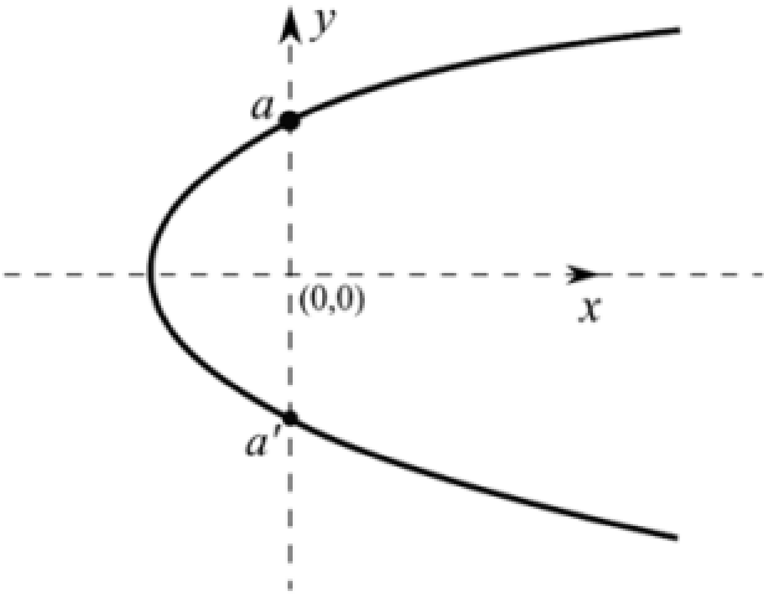


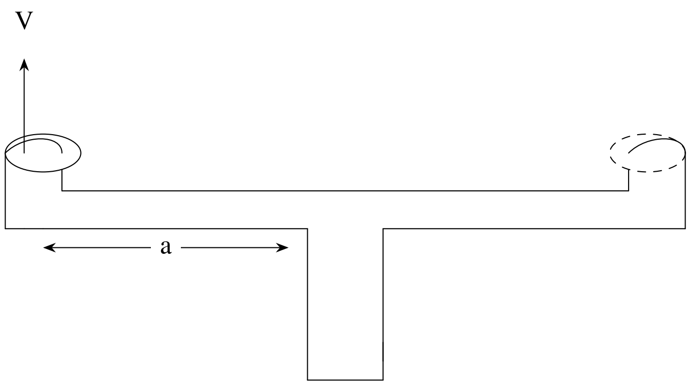
Fig. 11

12) For an inviscid fluid with density 1 kg/m^3, the Cartesian velocity field is given as:

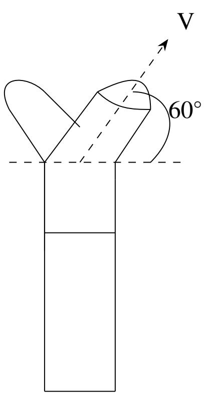
$$\mathbf{u} = (-2x + y)i + (2x + y)j \text{ m/s}$$

Neglecting the body forces, find the magnitude of pressure gradient in (Pa/m) at $(x, y) = (1 \text{ m}, 1 \text{ m})$ at $t = 1$ s.
(Round off to two decimal places)

13) Consider a lawn sprinkler with horizontal arms of radius, $a = 10$ cm which has water inlets vertically through the centre, as shown in the figure. The exit area of the jet is 25 cm^2 and the jet velocity is 1 m/s. The water is ejected orthogonal to the sprinkler arm and the jet makes an angle of 60° with the horizontal plane. Find the torque (in N·m) required to hold the sprinkler stationary.
Consider water density 1000 kg/m^3. Neglect the effects of friction and gravity.
(Round off to two decimal places)



Front view



Side view