Fluid Kinematics

1. The velocity vector in an incompressible fluid flow is given by, $\mathbf{V} = (6xt + yz^2)\mathbf{i} + (3t + xy^2)\mathbf{j} + (xy - 2xyz - 6tz)\mathbf{k}$.
   (i) Verify whether flow is possible. (ii) Determine the acceleration vector at point A (1,1,1) at t= 1.0 sec.
   [Ans: Yes; $a = 38i+18j+39k$]

2. A velocity field is given by $\mathbf{V} = 10x^2y\mathbf{i} + 15xy\mathbf{j} + (25t - 3xy)\mathbf{k}$. Characterize the flow field as steady or unsteady; Find the total acceleration of a fluid particle at point (1, 2, -1) and time t = 0.5sec.
   [Ans: Unsteady; 1531.9 unit]

3. The velocity along the centerline of a nozzle of length L is given by $V = 2t\left(1 - \frac{x}{2L}\right)^2$, where V=velocity in m/s, t=time in seconds from commencement of flow, x=distance from inlet to nozzle. Find the convective acceleration, local acceleration and total acceleration when t=3s, x=0.5m and L=0.8m.
   [Ans: a_{conv}= -14.623m/s^2; a_{local}= 0.945m/s^2; a_{total}= -13.68m/s^2]

4. For a steady incompressible fluid flow through a nozzle, the velocity field is given by $\overline{V} = u_0\left(1 + \frac{2x}{L}\right)i$ where x is the distance along the axis of the nozzle from its inlet plane and L is the length of the nozzle. Find
   (i) an expression of the acceleration of a particle flowing through the nozzle, and
   (ii) the time required for a fluid particle to travel from the inlet to the exit of the nozzle.
   [Ans: (i) $a = \frac{2u_0^2}{L}\left(1 + \frac{2x}{L}\right)$ (ii) $t = \frac{L}{2u_0}\ln 3$]

5. A flow velocity vector is given by $\mathbf{V} = 3x\mathbf{i} + 4y\mathbf{j} - 7z\mathbf{k}$. Determine the equation of the streamline passing through a point M=(1,4,5).
   [Ans: $y = 4x^{4/3}$; $z = 5/x^{7/3}$]

6. The velocity for a steady, incompressible fluid flow in the x-y plane is given by $\overline{V} = \left(\frac{A}{x}\right)i + \left(\frac{Ay}{x^2}\right)j$ where A=2m^2/s and the coordinates are measured in meters. Obtain an equation for the streamline that passes through the point (x, y) =(1, 3). Calculate the time required for a fluid particle to move from x = 1m to x= 3m in this flow field.
   [Ans: y=3x; t =2 sec]

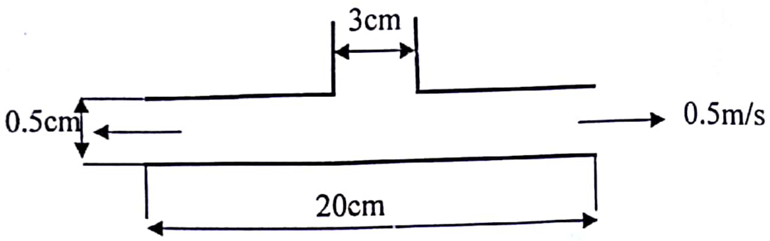
7. A two dimensional flow is described in the Lagrangian coordinate system as
   $$x = x_0 e^{-kt} + y_0\left(1 - e^{-2kt}\right), \qquad y = y_0 e^{kt}$$
   Find the equation of path line of the particle and the velocity components in Eulerian system.
   [Ans: $(x - y_0)y^2 - x_0 y_0 y + y_0^3 = 0$; $u = -kx + ky(e^{-kt} + e^{-3kt})$, $v = ky$]

8. For a flow in x-y plane, the y component of velocity is given by $v = y^2 - 2x + 2y$ Determine the x-component of velocity, for a steady incompressible fluid flow, if u=0, at x=0.
   [Ans: $u = -2yx - 2x$]

9. The pipeline 60 cm in diameter bifurcates at a Y junction into two branches 40 cm and 30 cm in diameter. If the rate of flow in the main pipe is 1.5m^3/ s, and the mean velocity of flow in the 30 cm pipe is 7.5 m/s, determine the rate of flow and velocity in the 40 cm pipe.
   [Ans: 0.97 m^3/s; 7.72 m/s]

10. An oil of viscosity 0.1 Pa-s and density 900 kg/m^3 flows through a pipe of diameter 50 mm with average velocity of 1.78 m /s. Find the Reynolds No of the flow.
    [Ans: Re= 801.9]

11. A diffuser consists of two parallel plates 20cm in diameter and 0.5cm apart and connected to a 3cm diameter pipe. If the streamlines are assumed to be radial in the diffuser, what mean velocity in the pipe will correspond to an exit velocity of 0.5m/s?



[Ans: V= 2.22m/s]

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