UCE-305 FLUID MECHANICS
Tutorial No. 5 (Kinematics)

Q1: The velocity field in a fluid flow is given by: $\bar{V} = 2x^3\hat{i} - 5xy\hat{j} + 4t\hat{k}$. Find the velocity and acceleration of a fluid particle at (1, 2, 3) at time t = 1.

Q2: A pipe converges uniformly from 800 mm to 400 mm over a length of 1.5 m. The discharge through the pipe is 100 litres per sec. Determine the acceleration at the middle of pipe. If discharge through the pipe now increases uniformly from 100 to 200 lps in 40 sec, determine the acceleration at the middle of pipe after 20 sec. The velocity distribution over any cross-section may be considered to be uniform.

Q3: Water flows through a pipe **AB** 1.2 m in diameter at 3 m/s and then passes through a pipe **BC** 1.5 m in diameter. At **C**, pipe branches. Branch **CD** is 0.8 m in diameter and carries one third of flow in **AB**. The flow velocity in branch **CE** is 2.5 m/s. Find the rate of flow in **AB**, velocity in **BC**, velocity in **CD** and diameter of **CE**.

Q4: A water tank has a 30 mm diameter inlet at **A**, a 40 mm diameter outlet at **B** and a 30 mm diameter controllable inlet at **C** as shown in **Figure 1**. If velocity of water at the inlet **A** is 2 m/s and the velocity of flow going out at **B** is 1.85 m/s, what should be the velocity at the inlet **C** so that water level in the tank does not change?

Q5: Given, $\mathbf{u = 2x^2, v = 2xyz}$. Examine whether these velocity components represent **2D** or **3D** flow. If **3D**, determine the unknown component of velocity.

Q6: Consider the flow field $\vec{V} = A\hat{i} + Bt\hat{j}$, where **A** = 2 m/s and **B** = 0.3 m/s^2. Obtain an equation for the path line followed by a particle located at (1, 1) at **t** = 0. Also, find the equations of streamlines through the same point at instant **t** = 0, 1 and 2.

Q7: Verify whether the flow field described by $\mathbf{u = xy^3z, v = -y^2z^2}$ **and** $\mathbf{w = (yz^2 - y^3z^2/2)}$ is rotational or irrotational. If rotational, determine the components of rotation about the three axes. Also, determine the shear strain rates and the direct strain rates.

Q8: A velocity field is given as: $\mathbf{u = (x + y)}$ and $\mathbf{v = (x^3 - y).}$ Determine the circulation around a closed curve defined by points: (**1, 0**) and (**0, 1**).

Q9: For a **2D** flow, the velocity potential is given by $\phi = \mathbf{x\,(2y - 1)}$. Determine the velocity at the point **P** (4, 5). Also, determine the stream function at the point **P**.

Q10: A flow is described by the stream function, $\Psi = \mathbf{3xy}$. Locate a point where the velocity vector has a magnitude of 5 units and it makes an angle of 128°45' with the x-axis.

Q11: Does stream function $\Psi = \mathbf{4xy}$ describe a possible steady and incompressible flow? If yes, find whether the flow is rotational or irrotational. Also, if this stream function describes the

flow between the boundaries as shown in **Figure 2**; calculate velocity & acceleration at **A** and the flow rate per unit width across **AB**.

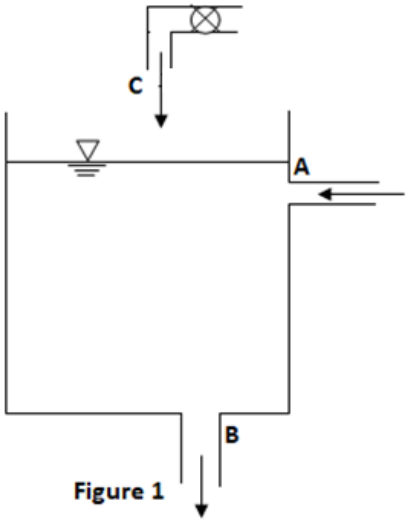

Figure 1

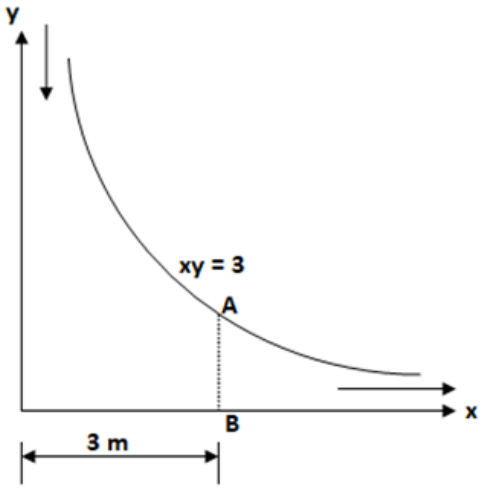

Figure 2

Answers:

Q1: 10.95, 32.56 **Q2**: 0.11 m/s^2, 0.258 m/s^2 **Q3**: 3.4 m^3/s, 1.92 m/s, 2.25 m/s, 1.07 m **Q4**: 1.28 m/s **Q5**: -4xz –xz^2 **Q6**: (y -1) = 0.0375 (x -1)^2; y = 1, 0.15 x – y + 0.85 = 0, 0.3 x - y + 0.7 = 0 **Q7**: -1.5 xy^{2}z, 0.5 (z^2 -1.5 y^{2}z^2 + 2 y^{2}z), 0.5 xy^3; 1.5 xy^{2}z, 0.5 (z^2 -1.5 y^{2}z^2 - 2 y^{2}z); 0.5 xy^3; y^{3}z, -2yz^2, (2yz – y^{3}z) **Q8**: 0 **Q9**: 12.04, - 4 **Q10**: (1.04, 1.3) **Q11**: 12.65, 50.6, 12.