Tutorial Sheet-II (MEC2310)

Q.1 A two dimensional flow is described in the Lagrangian system as

$$x = x_0 e^{-kt} + y_0 (1 - e^{-2kt})$$
$$y = y_0 e^{kt}$$

Find (a) the equation of path line of the particle and (b) the velocity components in Eulerian system.

Q.2 Given a velocity field V = (4 + xy + 2t) i + $6x^3$ j + ($3xt^2$ + z) k . Find the acceleration of a fluid particle at (2, 4, -4) and time t = 3.

Q.3 The velocity field in a fluid medium is given by V = $3xy^2$ i + 2xy j + (2zy + 3t) k
Find the magnitudes and directions of (i) translational velocity, (ii) rotational velocity and (iii) the vorticity of a fluid element at (1, 2, 1) and at time t = 3.

Q.4 Find the acceleration of a fluid particle at the point r = 2a, θ= π/2 for a 2-dimensional flow given by

$$V_r = -u\left(1 - \frac{a^2}{r^2}\right)\cos\theta, \quad V_\theta = u\left(1 + \frac{a^2}{r^2}\right)\sin\theta$$

Q.5 A two-dimensional flow field is defined as V = ix - jy. Derive the equation of stream line passing through the point (1, 1).

Q.6 A three-dimensional velocity field is given by
u(x, y, z) = cx + $2w_0y$ + u_0
v(x, y, z) = cy + v_0
w(x, y, z) = -2cz + w_0 :
where c, w_0 , u_0 , and v_0 are constants. Find the components of (i) rotational velocity, (ii) vorticity and (iii) the strain rates for the above flow field.

Q.7 The velocity potential function for a flow is given by Φ = $x^2 – y^2$. Verify that the flow is incompressible and then determine the stream function for the flow.

Q.8 Does a velocity potential function Φ = 2(x^2 + 2y - y^2) describe the possible flow of an incompressible fluid? If so, find out the equation for the velocity vector **V**. Also determine the equation for streamlines.

Q.9 A two dimensional source of strength ***K*** = 2.5 m^2/s is located in a uniform flow (U_0) of 2 m/s. Determine the stagnation point and the maximum thickness of resulting half body.

Q.10 A line source discharging a flow at 0.6 m^2/s per unit length is located at (-1,0) and a sink of volume flow rate 1.2 m^2/s is located at (2,0). For a dynamic pressure of 10 N/m^2 at the origin, determine the velocity and dynamic pressure at (1,1).

Q.11 A source with volume flow rate 0.2 m^2/s and a vortex with strength 1 m^2/s are located at the origin. Determine the equations for velocity potential and stream function. What should be the resultant velocity at x = 0.9 m and y = 0.8 m?

Q.12 A 300 mm diameter circular cylinder is rotated about its axis in a stream of water having a uniform velocity of 5 m/s. Estimate the rotational speed when both the stagnation points coincide. Estimate the lift force experienced by the cylinder under such condition. density of water may be assumed to be 1000 kg/m^3 .

Q.13 Consider a non-lifting flow over a circular cylinder. Calculate the locations on the surface of the cylinder where the surface pressure equals the free stream pressure.

Q.14 Prove that streamlines and equipotential lines are orthogonal.

Q.15 A source and sink of equal strength located on the x-axis at x=a, and x=-a, respectively. For any point 'p' in the flow domain finds the superimposed stream function and potential function for new flow in Cartesian system of coordinates. Show that the pattern of streamline represented by ψ=constant is a circle. Find the radius of the circle.