Before answering the question paper the candidate should ensure that they have been supplied the correct question paper. Complaints in this regard, if any, shall not be entertained after the examination.

Note: Question No. 1 is Compulsory and attempt two questions from each section. All questions carry equal marks.

1(a) Find the velocity components at a point (1, 1, 1) for the following flow field

\[ \mu = 2x^2 + 3y, \nu = -2xy + 3y^2 + 3yz, \omega = \frac{3}{2}z^2 + 2xz - 9y^2z \]

(b) Describe universal velocity distribution law.
(c) Find the value of boundary layer thickness on a flat plate by approximate method.
(d) Explain Stokes approximation.
(e) The flow of an incompressible fluid is defined by \( u = 3, v = 8x \). Does a stream function exist? If so, find its expression.

SECTION-A

2. The velocity field in a fluid medium is given by

\[ \vec{v} = 3xy^2 \hat{i} + 2xy^2 + (2xy + 3t)\hat{k} \]

Find the magnitudes and directions of
(i) translational velocity (ii) rotational velocity (iii) the vorticity of a fluid element at (1, 2, 1) and at time \( t = 3 \)

3. Compressed air exhaust from a small hole in a rigid spherical tank at the mass flow rate of \( m_o \) which is proportional to the density \( \rho \) of the tank. If \( \rho_o \) is the initial density in the tank of volume \( V \), derive an expression for the density change as the function of time after the hole is opened. Assume uniform density with in the tank. Assume diameter of the tank as 60 cm with original pressure of 400 kPa and temperature of 400 K. Initial exhaust rate of air through the hole is 0.02kg/s. Find the time required for the tank density to drop by 40%.

4. Air at standard conditions flows over a flat plate. The free stream speed is 3m/sec. find \( \delta \) and \( T\omega \) at x=1 from the leading edge (assume a cubic velocity profile) for air \( \nu = 13.5 \times 10^{-5} m^2/s \) and \( \rho = 1.23 kg/m^3 \)

SECTION-B

5. A two-dimensional flow is described in the langrange system as

\[ x = x_0 e^{-kt} + y_0 (1 - e^{-kt}) \]

\[ y = y_0 \]

Find (a) the equation of fluid particle in the flow field and (b) the velocity components in the Eulerian system

6(a) Describe Couette flow.
(b) Water at 60°C flows between two large flat plates. The lower plate moves to the left at a speed of 0.3 m/s. The plate spacing is 3 mm and the flow is laminar. Determine the pressure gradient required to produce zero net flow at a cross section (\( \mu = 4.7 \times 10^{-4} Ns/m^2 \)) at 60°C.

7. Explain Prandtl mixing length Hypothesis.