FN

**Date of Examination: 24.09.2018 Session (FN/AN) AN Duration 2 Hrs Full Marks 30**
**Subject No.: MA40011 Subject: FLUID MECHANICS**
**Department / ~~Center~~/ ~~School~~ Mathematics**
**Specific Charts, graph paper, log book etc., required Nil**
**Special Instructions (if any) : Calculators of any type are not allowed.**

***General Instructions***: *Answer all the questions. No marks will be awarded without showing proper steps. Notations and symbols have their usual meaning. Marks distribution is given after each question.*

1(a). The velocity profile for flow over a flat plate by is given by $u(y) = (0.49\ln y - \ln(8.5 - y))$ m/sec at a distance $y$ meter above the plate. If the viscosity of the fluid is $\mu_0$, derive at what height from the plate the shear stress will be minimum.

1(b). A velocity field in the cylindrical polar coordinates $\vec{q} = \left(\frac{1}{r}, \frac{1}{r}, 0\right)$. Find whether or not this velocity field represents an incompressible flow. Determine the streamline passing through the point $\left(1, \frac{\pi}{2}, 0\right)$. (2+4)

2(a). Derive an expression for the velocity $q_n$ of a fluid that is normal to the boundary surface $h(x,y,z,t) = 0$. Also find $q_n$ when the boundary is fixed.

2(b). The cross-sectional area of a nozzle converges linearly along its length. The diameters at inlet and outlet are $D_1$ and $D_2$ respectively and axial length is $L$. Determine the convective acceleration of a fluid at a section halfway along the axis of the nozzle, if the discharge is constant at $Q$. (2+4)

3(a) In the Bernoulli's equation $\frac{q^2}{2g} + \frac{p}{\rho g} + z = constant$, what does each term represent? Give answer with proper justification.

(b) A steady inviscid incompressible flow has a velocity field $(\alpha x, -\alpha y, 0)$, where $\alpha$ is a constant. Using Euler's equation of motion, derive an expression for the pressure field $p(x,y,z)$ if the pressure $p(0,0,0) = p_0$ and the external force $\vec{F}$ is given by $\vec{F} = -gz\hat{k}$. (2+4)

4. Consider the steady adiabatic potential flow of a gas through a converging pipe. Assuming that there is no body force, show that the speed of the flow is an increasing function of the length of the pipe if the flow is subsonic. (For an adiabatic flow the pressure $p$ and the density $\rho$ are connected by the law $p = K\rho^\gamma$; $K, \gamma$ are positive constants with $\gamma > 1$. Also the speed $c$ of sound inside the gas is given by $c^2 = \frac{dp}{d\rho}$). (7)

5. Determine the circulation of a velocity field $\vec{q} = \left(-\frac{y}{x^2+y^2}, \frac{x}{x^2+y^2}\right)$ around the boundary of the square with vertices at (1,0), (2,0), (2,1), (1,1). (5)

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