INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Date: 16 .09.2015, AN, Time: 2 Hrs, Full Marks: 30, Deptt: MA
No. of Students: 57, Mid-Autumn Semester Examination, 2016
Sub. No. MA40011, Sub. Name: Fluid Mechanics

Instruction: *Answer all the questions. No marks will be awarded without showing proper steps.*

1. The velocity distribution of flow over a plate is parabolic with vertex $30cm$ from the plate, where the velocity is $180cm/sec$. If the viscosity of the fluid is $0.9Ns/m^2$, find the shear stresses at distances 0 and $15cm$ from the plate. (4m)

2. If $\vec{q} = (q_r, q_\theta, q_\varphi)$ and $\vec{a} = (a_r, a_\theta, a_\varphi)$ denote the velocity and the acceleration respectively of a fluid particle in spherical polar coordinates (r, θ, φ), find a_r, a_θ, a_φ. (5m)

3. The velocity field of a fluid flow is given by $\vec{q} = 4x\hat{\imath} + 6y\hat{\jmath} - 10z\hat{k}$.
(a) Find the equation of the streamline in the form $xyz=k$ (k=constant), given that the streamline passes through the point (1, 4, 5).
(b) Also, find the equation of the pathline passing through the point (1, 4, 5) at time $t=1$. (5m)

4. (a) Check whether $u = -\frac{2xyz}{(x^2+y^2)^2}, v = \frac{(x^2-y^2)z}{(x^2+y^2)^2}, w = \frac{y}{x^2+y^2}$ are the velocity components of a possible liquid motion.
(b)Whether the motion is irrotational.
(c) If it is, find the corresponding velocity potential $\varphi(x, y)$. (6m)

5. Water is flowing through a pipe having diameters $300mm$ and $200mm$ at sections 1 and 2 which are $10m$ and $2m$ above datum(reference horizontal line). If the rate of flow through the pipe is 400 *lit/min*, find the pressure of water at section 2 and its total energy per unit mass. (5m)

6. State and prove Kelvin's minimum energy theorem. (5m)

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