B.Printing Engineering 3rd YR 1ST Supplementary SEM EXAM - 2017

FLUID MECHANICS TIME:3 H FULL MARKS :100

Answer any Five questions

1. a. Derive Navier-Stokes Equation starting from Reynold's Transport Theorem
   b. Derive Hagen Poiseuille Flow

[10+10=20]

2. a. For turbulent flow in a pipe, find the value of distance y from a wall where the point velocity becomes the average velocity, v.

   b. For turbulent flow in pipe for both smooth and rough pipes, find the value of $\frac{v_{max}}{V}$ in terms of friction factor f.

   c. A pipeline carrying water has an average roughness height k_s=0.3 mm. What type of boundary it is? The shear stress at the wall is 8.47 N/m^2. Take $\nu = 0.02$ stokes.

   d. The velocity profile in a laminar flow is given by $\frac{v}{V_s} = \frac{3}{2}\left(\frac{y}{\partial}\right) - \frac{1}{2}\left(\frac{y}{\partial}\right)^3$. A plate 2m long and 1.4m wide is placed in flowing water whose upstream velocity is 0.2 m/sec. If viscosity $\mu = 0.02$ poise, find the boundary layer thickness at a distance of 2 m from the leading edge. Also, find λ_o and F_D on both sides of the plate.

   OR

   The critical depth y_c in a triangular channel is a function of the discharge and acceleration g due to gravity. Show by the Rayleigh method, $y_c = \left(\frac{Q^2}{g}\right)^{1/5}$

   e. The velocity profile within the boundary layer is given by $\frac{v}{V_s} = \frac{3}{2}\left(\frac{y}{\partial}\right)^{1/7}$. Calculate displacement and energy thickness.

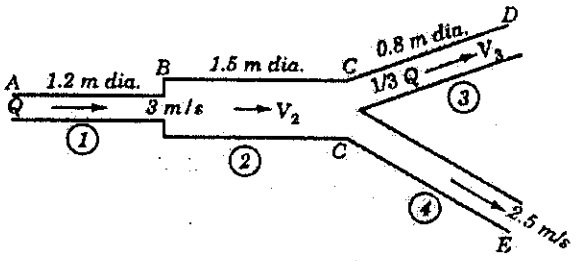
   f. For the velocity profile given below, state whether the boundary layer has separated or is on the verge of separation or will remain attached with the boundary surface.

   i) $\frac{v}{V_s} = \frac{3}{2}\left(\frac{y}{\partial}\right) - \frac{1}{2}\left(\frac{y}{\partial}\right)^2$ ii) $\frac{v}{V_s} = 2\left(\frac{y}{\partial}\right)^2 - \left(\frac{y}{\partial}\right)^3$ iii) $\frac{v}{V_s} = -2\left(\frac{y}{\partial}\right) + \left(\frac{y}{\partial}\right)^2$

[3+4+3+3+4+3=20]

3. a. Derive Bernoulli's Equation starting from Euler's equation of motion
   b. Derive the Continuity Equation in three-dimensional plane.
   c. At a point in the pipeline where the diameter is 20 cm, the velocity of water is 6 m/s and the pressure is 350 kN/m^2. At a point 20 m downstream the diameter reduces to 7m. Calculate the pressure at this point, if the pipe is a) horizontal b) vertical with flow downward c) vertical with flow upward.
   d. Water flows through a pipe AB 1.2 m diameter at 3 m/s and then passes through a pipe BC 1.5 m diameter. At C, the pipe branches. Branch CD is 0.8 m in diameter

and carries one-third of the flow in AB. The flow velocity in branch CE is 2.5 m/s. Find the volume rate of flow in AB, the velocity in BC, the velocity in CD and diameter of CE.



[3+3+6+8=20]

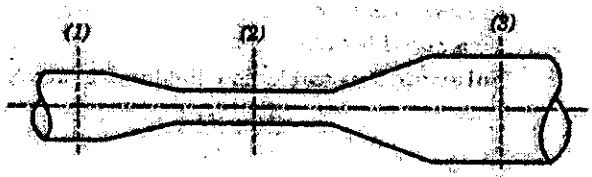
4. a. A coal slurry is to be transported by horizontal pipeline. It has been determined that the slurry may be described by the power law model with a flow index of 0.4, an apparent viscosity of 50 cP at a shear rate of 200/s, and a density of 90 lb/ft^3. What horse power would be required to pump the slurry at a rate of 900 GPM through an 8 in. Schedule 40 pipe that is 50 miles long?

b. Capillary rise h depends on density ρ, acceleration due to gravity g, surface tension σ and radius of the tube r. Show by using the Buckingham π-theorem that $\frac{h}{r} = \phi\left(\frac{\sigma}{\rho g r^2}\right)$

c. Derive the expression for laminar sub-layer.

d. An incompressible fluid flows through the circular pipe as shown in in the figure at the rate of Q m^3/s,

(i) If it is assumed that the velocities at sections (1), (2) and (3) are uniform, what are the velocities given that the diameters of the pipe at the three sections are d_1, d_2 and d_3 metre respectively.



(ii) Determine these velocities for Q=0.3 m^3/s, d_1 = 0.4 m, d_2 = 0.2 m and d_3 = 0.75 m.

(iii) Find the velocities when Q = 0.3 m^3/s at section (1) but the density changes in such a way that $\rho_2 = 0.5\ \rho_1$, $\rho_3 = 1.3\ \rho_1$. The flow is steady in all cases. The diameters are same as given for (ii).

[5+5+5+5=20]

5. a. Prove that for a 2-D incompressible, irrotational flow the streamlines and equipotential lines are always orthogonal.

b. Derive the expression for "COUETTE FLOW"

[10+10=20]

6. a. Define
   - (i) Reynolds Number
   - (ii) Froude's Number
   - (iii) Weber Number
   - (iv) Mach Number
   - (v) Euler Number

b. A spillway 7.2 m high and 150 m long discharges 2150 m^3/sec under a head of 4 m. If 1:16 model of spillway is to be constructed, find the model dimensions, head over the model and model discharge.

c. A model in the scale $\frac{1}{15}$ of a boat is towed in water. The prototype is moving in sea water of density 1024 kg/m^3 at a velocity 20 m/sec. Find the corresponding velocity of the model in water and resistance due to wave in the model if the resistance in prototype due to the wave is 600 N.

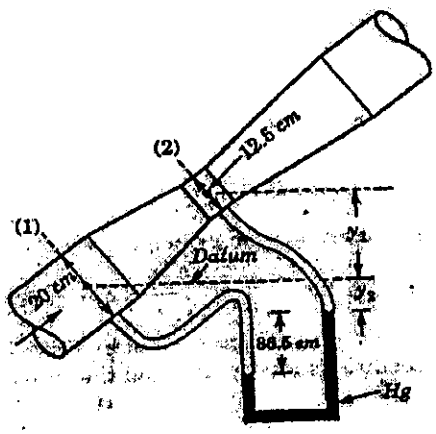
[2*5+4+6=20]

7. a. If the expression for the stream function is described by $\psi = x^3 - 3xy^2$, determine whether the flow is (i) rotational or (ii) irrotational. If the flow is irrotational, then indicate the correct value of the velocity potential:

i) $\phi = y^3 - 3x^2y$ ii) $\phi = -3x^2y$

b. The velocity field in a fluid flow is given by $\bar{v} = 10x^2y\hat{i} + 15xy\hat{j} + (25t - 3xy)\hat{k}$. Find acceleration of flow at (1, 2, -1) m at time t=0.5 s.

c. A 20-cm water pipe has in it a venturimeter of throat diameter 12.5 cm as shown in the figure, which is connected to a mercury manometer showing difference of 86.5 cm. Find the velocity in the throat and the discharge.



d. Draw a centrifugal pump showing its components

[4+4+6+6=20]

8. a. A horizontal pipe of diameter 400 mm is suddenly contracted to 200 mm. The pressure intensities in the large and smaller ends of the pipe are given as 14.715 N/cm^2 and 12.753 N/cm^2 respectively. If C_c =0.62, find the loss of head due to sudden contraction. Also, determine the discharge

b. Derive the expression for laminar sub-layer.

c. Derive the Bernoulli equation for steady incompressible flow from the Euler equation for an inviscid fluid. Between which two points is the derived Bernoulli equation valid?

[6+4+10=20]

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Supplementary Section