THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
BACHELOR OF TECHNOLOGY – LEVEL 05
FINAL EXAMINATION 2005/2006
MEX5230 – FLUID MECHANICS
DATE : 15th MARCH 2006
TIME : 0930-1230 HOURS
DURATION : THREE HOURS

ANSWER FIVE QUESTIONS ONLY. ALL QUESTIONS CARRY EQUAL MARKS.

(Viscosity of water = 1×10^{-6} m^2/s, Density of water = 1000kg/m^3)

1. A tank ABCDE shown in Figure Q1 contains water upto a depth of 1m and is 2m wide in the direction of Y . The curve AB is defined by $z = x^2$ and curve CD is a quadrant of a circle of radius 0.3m. Calculate the magnitude of the resultant forces on surfaces AB and CD. Find also the angle that each resultant force makes with the horizontal.

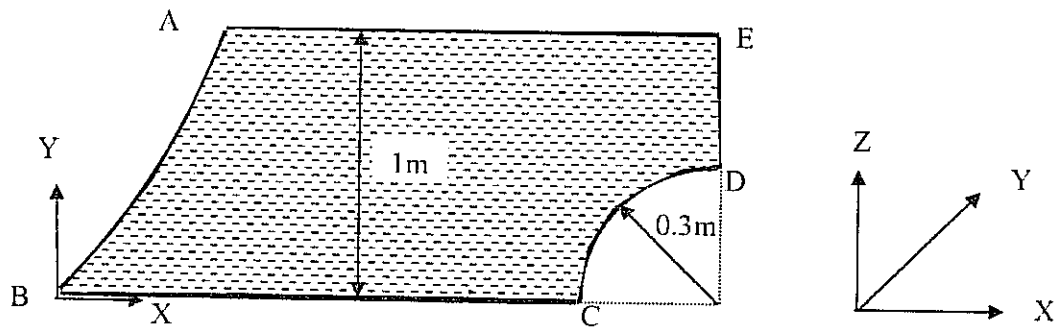


Figure Q1

2. Does the velocity potential $\Phi = \frac{-A\cos\theta}{2\pi r}$ represent a possible irrotational flow? If so, determine the stream function for the flow.
   A circular cylinder 0.5m diameter rotates at 600rev/min in a uniform stream of 15m/s.
   I. Locate the stagnation points.
   II. Calculate the minimum rotational speed for detached stagnation points.

3. State Buckingham's π theorem.
   Using this theorem, show that the discharge Q consumed by an oil ring is given by

$$Q = Nd^3\phi\left[\frac{\mu}{\rho Nd^2}, \frac{\sigma}{\rho N^2 d^3}, \frac{w}{\rho N^2 d}\right]$$

where **d** is the internal diameter of the ring, **N** is the rotational speed, **ρ** is density, **μ** is viscosity, **σ** is surface tension and **w** is specific weight of oil.

7.

4. The momentum integral equation of a two dimensional boundary layer is given below. Explain the significance of each term in the equation.

$$\frac{d\left(U^2\theta\right)}{dx}+\delta^* U\frac{dU}{dx}=\frac{\tau_0}{\rho}$$

A thin rectangular flat plate of length 2m and width 1m is held in an uniform stream of water of velocity 2m/s. The long side of the plate is held parallel to the direction of flow. A laminar boundary layer forms on the plate and its velocity profile may be approximated as,

$$\frac{u}{U}=1.5\left(\frac{y}{\delta}\right)-0.5\left(\frac{y}{\delta}\right)^3$$

where δ is the boundary layer thickness, U is the free stream velocity and y is the distance from the plate.
Calculate the total drag on the plate.

5. Prove that the discharge through a fully submerged orifice is,

$$Q=C_d b(H_2-H_1)\sqrt{2gH}$$

and for partially submerged orifice is,

$$Q=C_d b(H_2-H_1)\sqrt{2gH}+\frac{2}{3}C_d b\sqrt{2g}\left(H_2^{3/2}-H_1^{3/2}\right)$$

8.

where, b = width of the orifice
H = difference of water level
H_1 = height of the water from top of the orifice
H_2 = height of the water from bottom of the orifice

A rectangular orifice of 2m width and 1.2m deep is fitted in one side of a large tank. The water level on one side of the orifice is 3m above the top edge of the orifice, while on the other side of the orifice the water level is 0.5m below its top edge. Calculate the discharge through the orifice if coefficient of discharge is 0.64.

6. A pipe line conveys 0.00833m^3/s water from an overhead tank to a building. The pipe is 2km long , 0.15m in diameter and friction factor f = 0.03. It is desired to increase the discharge by 30% by installing another pipeline in parallel with this over half the length. Suggest a suitable diameter for the pipe to be installed, if the friction factor is the same. Neglect all the losses except losses due to friction of the pipe.

7. A piping system is shown in Figure Q7. Considering all losses, determine the pressure head on the suction and discharge sides of the pump and the power of motor needed to run the pump if the pump and motor efficiencies are each 70%. Note that the head loss for nozzle is

$$h_L = \frac{\left(1 - C_v^2\right)}{C_v^2} \frac{V_j^2}{2g}$$

C_v = coefficient of velocity and V_j = velocity through the nozzle.

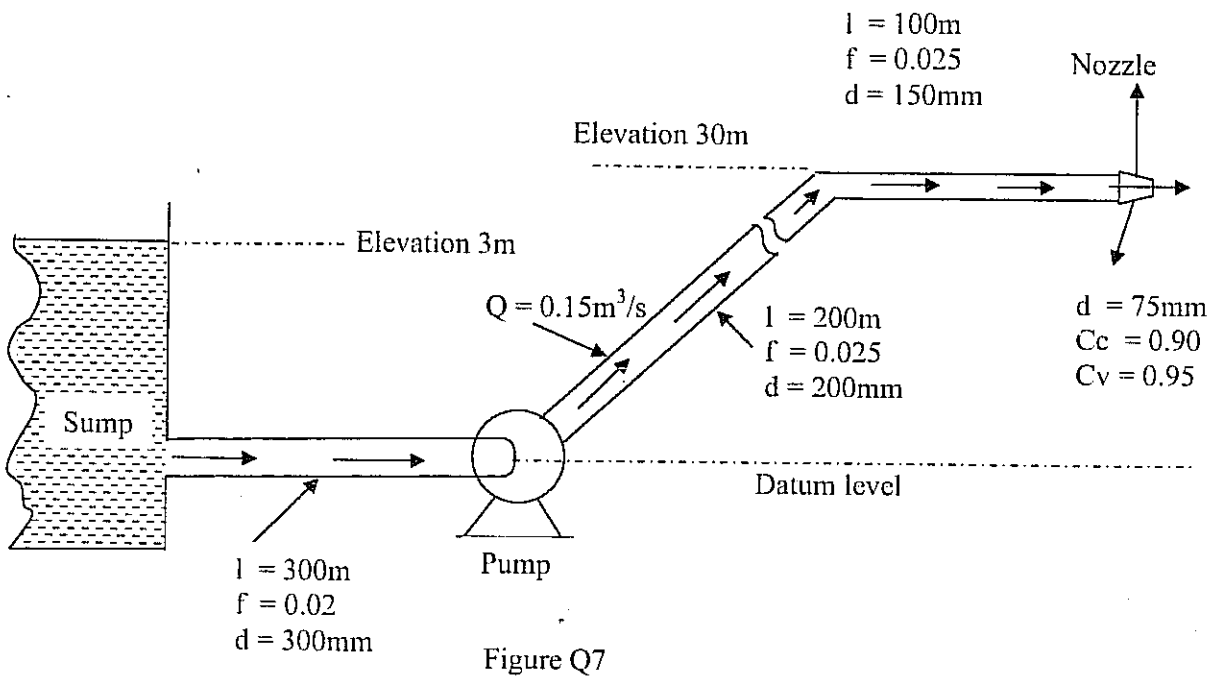


Figure Q7

8. Figure Q 8 shows a flow domain in the Z-plane bounded by the positive x and y axis and a circular are of radius 'a' centered on the origin. Fluid is injected through a slit at the rate 2πm volume/unit length of the slit/second. If the pressure far away is zero, obtain an expression for the pressure along the curved wall.

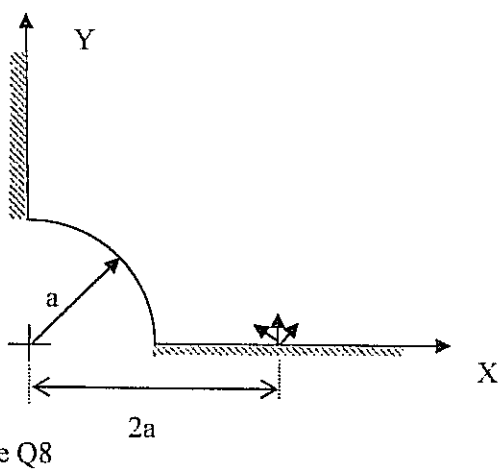


Figure Q8

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