UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 2 Examination in Engineering: December 2015

Module Number: CE2201 **Module Name: Fundamentals of Fluid Mechanics**

[Three Hours]

[Answer all questions]

Q1. Figure Q1 shows a rectangular gate HJ of negligible weight smoothly hinged at H to the side of an open tank. The tank contains a liquid 'A' of variable density to a depth of 1.5 m and a liquid 'B' of constant density to a depth of 1.2 m. The gate is 0.8 m wide normal to the plane of the figure and is kept just closed by a vertical force 'P' applied at J.

a) Draw the pressure diagram on HJ.

b) Find the force 'P', and the horizontal and vertical reactions at the hinge H.

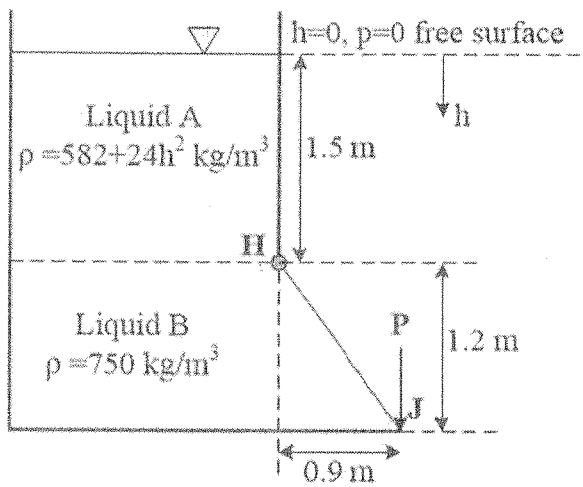

Figure Q1

[10.0 Marks]

Q2. The homogeneous block of wood shown in Figure Q2 has a symmetrical vertical section and a length 'l' normal to the plane of the figure. The block floats in water with the trapezoidal part below the free surface.

a) Show that the equilibrium is stable if $b^2 > \frac{10}{9}h^2$

b) Find the righting moment for a block having $l = 2.5\ m, b = 1.2\ m, and\ h = 0.6\ m$

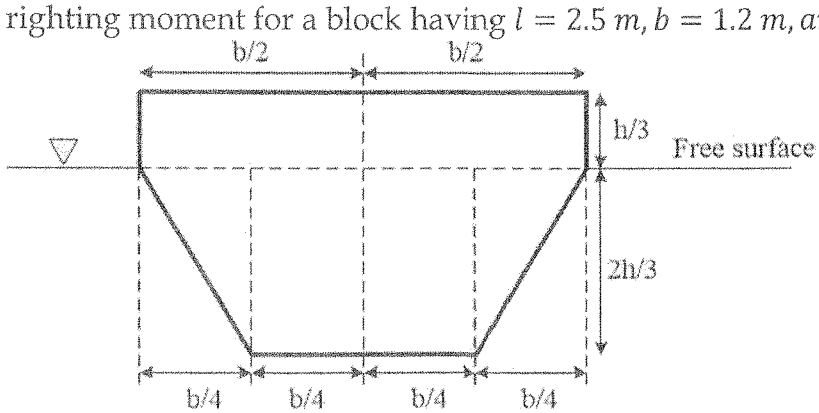

Figure Q2

[10.0 Marks]

Q3. A liquid of constant density ρ flows steadily in a horizontal circular pipe of radius r_o with the velocity varying across the pipe section as shown in Figure Q3.

At section 1: $u = U_1$ for $0 < r < \frac{r_o}{2}$

$u = 2U_1/3$ for $\frac{r_o}{2} < r < r_o$

At section 2: $u = U_2\left(1 - \frac{r^2}{r_o^2}\right)$

Show that $U_2 = 3U_1/2$ and the force on the pipe section between (1) and (2) is $\pi r_o^2\left(p_1 - p_2 - \frac{1}{6}\rho U_1^2\right)$, where p_1, p_2 are pressures at section 1 and section 2, respectively.

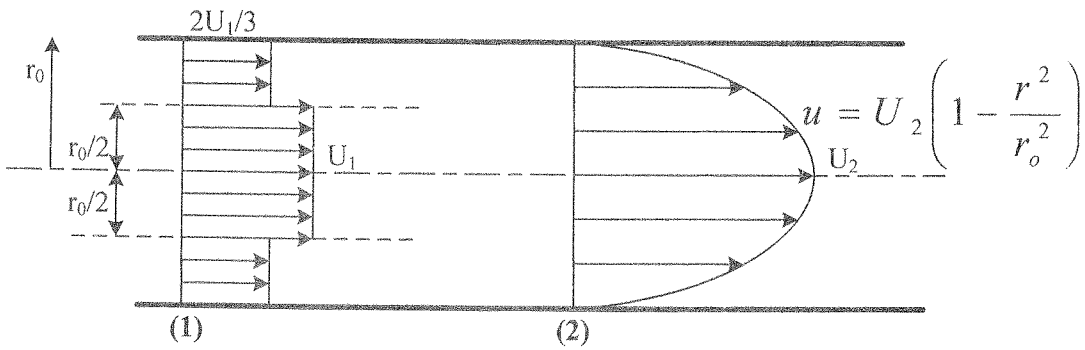

Figure Q3

[10.0 Marks]

Q4. A large rectangular tank partitioned by an inner wall has a rectangular orifice of width 1 m and height 0.5 m as shown in Figure Q4.

a) Derive an equation to find the discharge through the orifice under following conditions,
   (i) When the water level in Tank B is below the bottom edge of the orifice (Figure Q4a).
   (ii) When the water level in Tank B is above the top edge of the orifice (Figure Q4b).

b) Calculate the discharge through the orifice when
   (i) $H_A = 5.0\ m$ and $H_B = 0.8\ m$
   (ii) $H_A = 3.8\ m$ and $H_B = 2.0\ m$
   (iii) $H_A = 4.6\ m$ and $H_B = 1.2\ m$

   Assume coefficient of discharge $C_d = 1$ for all situations.

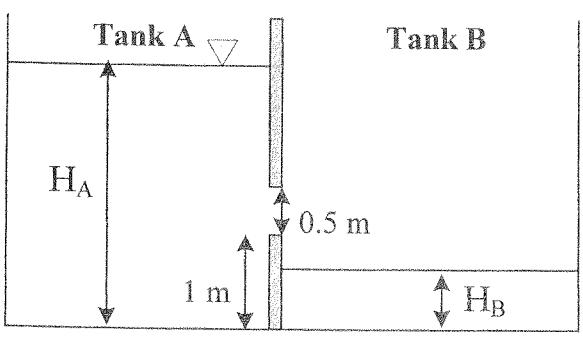

Figure Q4a

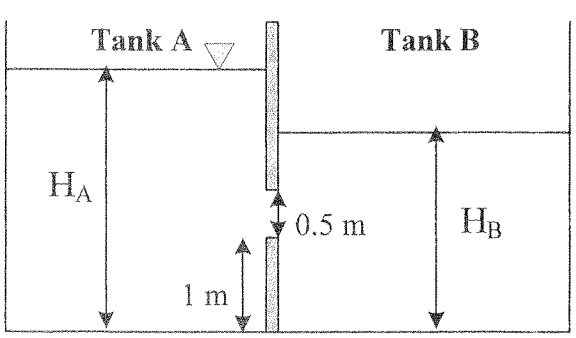

Figure Q4b

[10.0 Marks]

Q5. Two large reservoirs are connected with a 820 mm diameter pipe having a length of 6000 m. The water surface elevation of the upper reservoir is 300 m and that of lower reservoir is 270 m. The frictional head loss is given by $h_f = f\frac{l}{d}\frac{V^2}{2g}$ and $f = 0.02$. Neglect losses other than friction.

a) Compute the discharge in the pipeline.

b) To raise the flow rate to 1.5 m^3/s, a pump is installed at the midpoint of the pipeline.

(i) What is the power required by the pump, given the efficiency of the pump as 80%.

(ii) Find the highest elevation to which the midpoint of the pipe can raise before the pump, if the cavitation occurs at 70 kPa. Atmospheric pressure is 100 kPa.

[10.0 Marks]

Q6. Water is discharged from a large reservoir to the atmosphere through a pipeline. Discharged water from the reservoir is directed to the buckets of a Pelton wheel through a nozzle as shown in Figure Q6.

a) If the Pelton wheel nozzle is located 300 m below the water surface of the reservoir and head loss in the pipeline is 25 m, calculate the velocity of the jet directed to the bucket. If the jet has an area of 2000 mm^2, find the discharge through the nozzle.

b) Water jet strikes the vane and reverses it through an angle of 120° without any energy loss. If the turbine is operating at 400 rpm and the wheel diameter is 2 m, calculate the power generated from the turbine. Neglect losses.

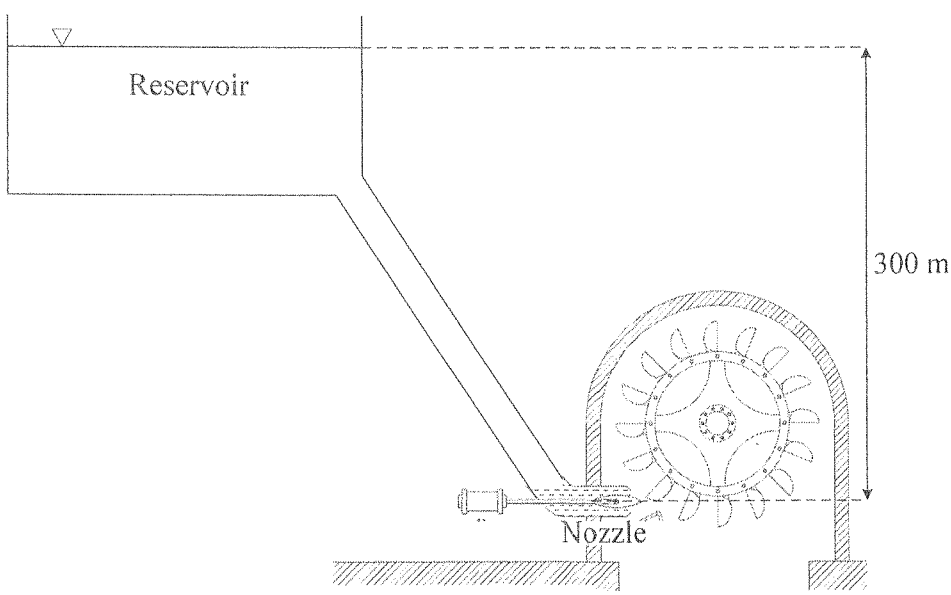

Figure Q6

[10.0 Marks]