UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 2 Examination in Engineering: December 2016

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

[Three Hours]

[Answer all questions]

Q1. A pair of gates AC and BC of a 7.5 m wide lock makes an angle of 120° with each other in the closed position. Figure Q1 shows the plan view of lock gates. Each gate is held on to the wall of the lock by two hinges which are 0.75 m and 6.25 m from the floor of the lock. The water depths are 9 m and 3 m on either side of the gates.

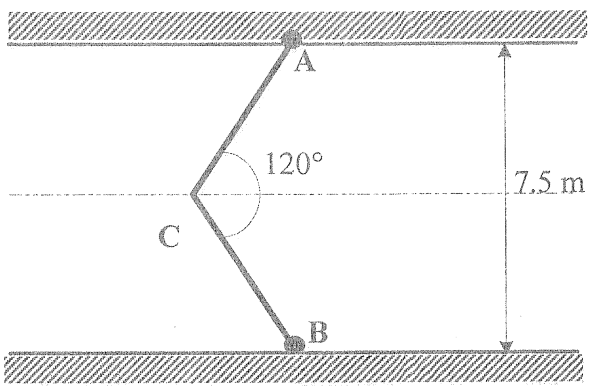

Figure Q1

a) Determine the net hydrostatic force on a gate and distance to its line of action from the floor.

[6.0 Marks]

b) Determine the reaction at the contact surface of gates and the force on each hinge.

[4.0 Marks]

Q2. A buoy floating in seawater of density $\rho = 1025$ kg/m^3 is conical in shape with a top diameter of 1.2 m and a vertex angle of 60°. Its mass is 300 kg and its centre of gravity is 750 mm from the vertex. A flashing beacon having a mass of 55 kg is to be fitted to the top of the buoy.

a) Find the draught of the whole assembly in sea water and the distance to the centre of buoyancy from the vertex.

[4.0 Marks]

b) Find the distance to the metacentre from the vertex.

[3.0 Marks]

c) What is the maximum height of centre of gravity of the flashing beacon above the top of the buoy for the stability of the whole assembly?

[3.0 Marks]

Q3. Figure Q3 shows a sluice gate in a wide open channel with negligible slope and negligible friction at the channel bed. The depth h_2 of water just downstream of the gate at section (2) is 0.3 m and the velocity profile is approximated by $u = 5\left(\frac{y}{0.3}\right)^{1/7}$ where u is the velocity in m/s at a distance y metres from the bed. At the upstream section (1) the depth is h_1 and the velocity is uniform at 0.8 m/s.

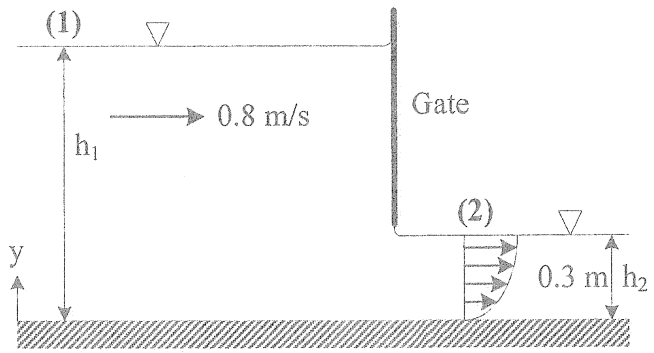

Figure Q3

a) Calculate the volume flow rate per metre width of channel.

[2.0 Marks]

b) Find the momentum flow rate in the flow direction at section (2).

[2.0 Marks]

c) Find the force per metre width on the gate assuming hydrostatic pressure variation over the upstream and downstream depths.

[6.0 Marks]

Q4. A horizontal Wye junction in a pipe KJ carrying oil of density 800 kg/m^3 at a volume flow rate of $Q_K = 280\ \ell/s$ is shown in figure Q4. The flow is divided into two streams Q_M along JM and Q_N along JN. The head loss along KJM is $0.325\ \frac{V_K^2}{2g}$ and the head loss along KJN is $0.3\ \frac{V_K^2}{2g}$ where V_K is the velocity at K. The flow is steady and one dimensional. The pressures at K and N are equal and the pressure at M is atmospheric.

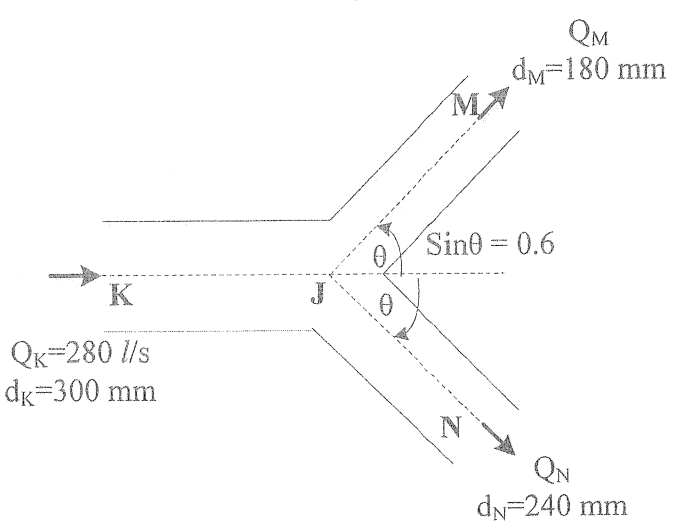

Figure Q4

a) Find the volume flow rate Q_N and pressure at N.

[5.0 Marks]

b) Find the force exerted on the Wye junction in magnitude and direction.

[5.0 Marks]

Q5. The horizontal lawn sprinkler JOK in figure Q5 with arms JO=OK=180 mm and two nozzles each of exit diameter 7.5 mm discharging to atmosphere at 90° to radial direction has a water flow rate of 1.4 ℓ/s introduced vertically through centre O.

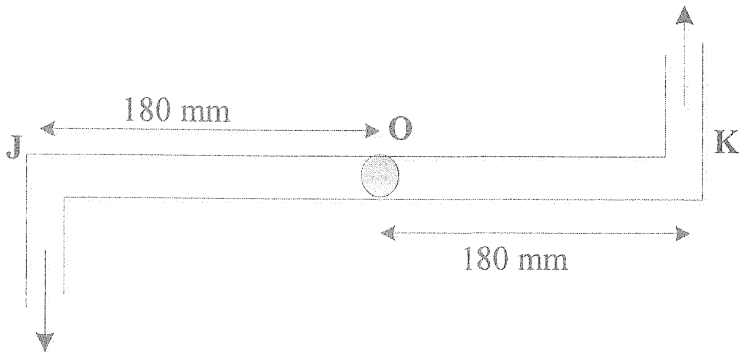

Figure Q5

a) If there is no retarding torque find the rotational speed of the sprinkler in rad/s.

[3.0 Marks]

b) Find the retarding torque required to reduce the rotational speed in (a) by 50%.

[4.0 Marks]

c) What is the retarding torque required to prevent the rotation of the sprinkler?

[3.0 Marks]

Q6. Water from a large open tank A discharges freely to atmosphere at B through a horizontal pipe AB of uniform diameter 300 mm and length ℓ . The level of the free surface in A is 12 m above the level of discharge end B. The head loss in the pipe AB is given by $(2 + 0.08\ell)\frac{V^2}{2g}$ where V is the velocity in the pipe.

a) Find the length ℓ of the pipe if the discharge at B is 280 ℓ/s.

[3.0 Marks]

b) If a short horizontal nozzle BN of exit diameter 150 mm having negligible head loss is fitted at the end B of the pipe find the new discharge at N.

[3.0 Marks]

c) If a pump P is fitted midway in AB to bring the discharge at N back to 280 ℓ/s find the head added by the pump and sketch the total head line.

[4.0 Marks]