University of Asia Pacific
Department of Civil Engineering
Final Examination Spring 2013

Course Title: Fluid Mechanics | Course No: CE 221
Time: 3.0 hour | Full Marks: 150

The symbols have their usual meanings.
The figures at the right margin indicate full marks.
There are **eight questions**. Answer **Question No. 7** as compulsory and **any five** from the rest.

1. (a) Define the following terms (any two): (2X3=6)
   i. Unsteady flow
   ii. Steam line
   iii. Control volume.

   (b) What do you mean by stream function? Write down the characteristics and limitations of flow net. (3+6=9)

   (c) In a flow the velocity vector is given by $V = 2xi - 3yj + 5zk$. Determine the equation of the streamline passing through a point M (3, 1, 2). (10)

2. (a) Derive Bernoulli's energy equation. Also state its limitations. (10+3=13)

   (b) A liquid (S= 0.80) with a P_v= 26 kN/m^2, abs flows through the horizontal constriction as shown in figure 1. P_{atm} = 68 cm Hg. Find the maximum theoretical flow rate without cavitation to occur). Neglect head loss. (12)

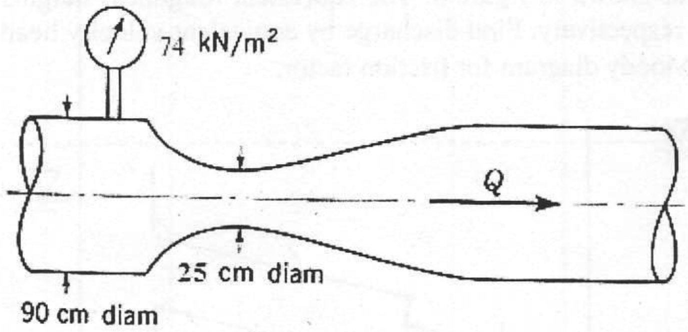

Figure 1

3. (a) Explain why a momentum correction factor is used. Also derive and expression for this factor. (3+5=8)

   (b) A Reaction Turbine has r_1 = 1.5 m, r_2 = 1.1 m, β_1 = 50^0, β_2 = 140^0, and thickness of 0.3 m parallel to the axis of rotation. With a guide vane angle of 20^0 and a flow rate of 12.0 m^3/s, calculate the required speed of the runner for smooth flow at inlet. For this condition also calculate:
   i. Torque exerted on the runner
   ii. Power developed
   iii. Energy extracted from each Newton of fluid. (17)

4. (a) Derive an expression for the drag force F_D exerted on a sphere as it moves through a viscous liquid by applying Rayleigh Method. (9)

   (b) A curved pipe section of length 10 m that is attached to the straight pipe section as shown in figure 2. Determine the resultant force on the curved pipe, and find the horizontal component of the jet reaction. All significant data are given in the figure. Assume an ideal fluid with γ = 8.80 kN/m^3. (16)

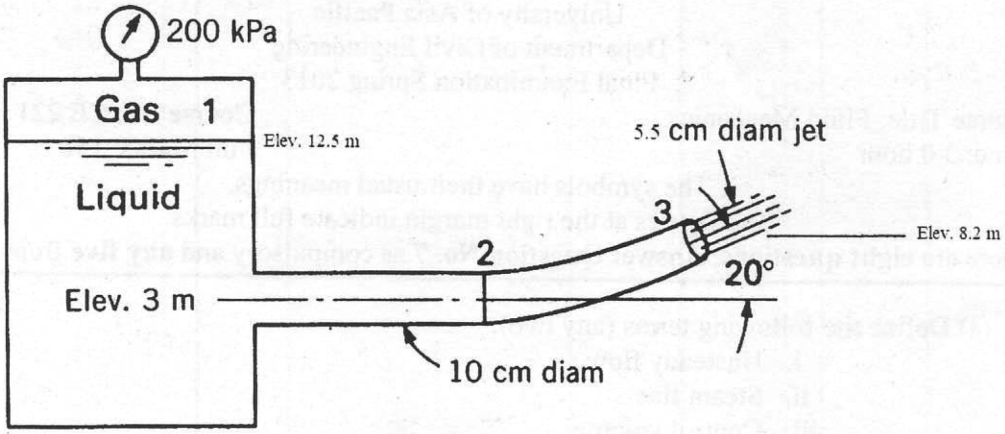

Figure 2

5. (a) A pipeline 40 m long is connected to a water tank at one end and discharges freely into the atmosphere at the other end. For the first 15 m of its length from the tank, the pipe is 20 cm in diameter and its diameter suddenly enlarges to 45 cm. The height of water level in the tank is 12 m above the center of the pipe. Considering all losses of head that occurs, determine the rate of flow. Assume f = 0.025 for both the pipes. (8)

(b) Two reservoirs with a difference in water surface elevation of 10 m are connected by two pipes in series as shown in figure 3. The equivalent roughness heights of the two pipes are 2.2 and 0.5 mm respectively. Find discharge by equivalent velocity head method. Given ν = 3×10^{-6} m^2/s. Use Moody diagram for friction factor. (17)

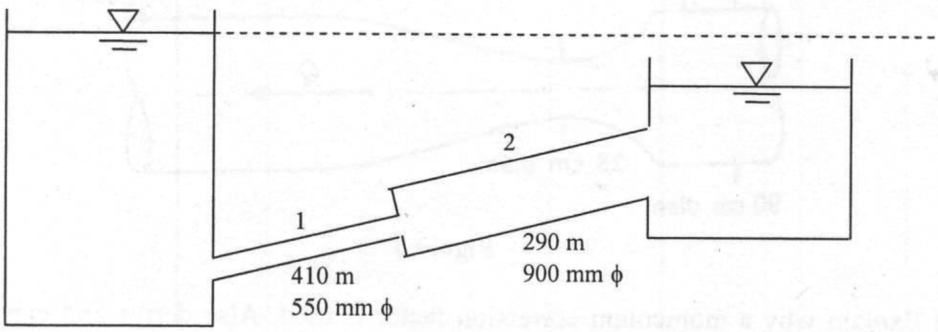

Figure 3

6. (a) Water is flowing through the pipe system as shown in figure 4. The pipe length, diameter and friction factor are given in figure. For a total discharge of 0.80 m^3/s, find flow through each pipe, head loss from B to C and pressure at C assuming P_B = 200 kN/m^2 and Z_B-Z_C = 5 m. (17)

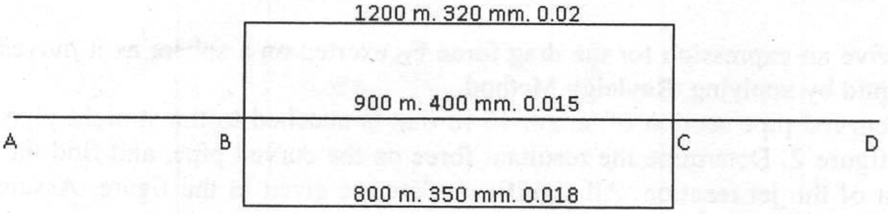

Figure 4

(b) If the flows into and out of a two-loop pipe system are as shown in figure 5, determine the flow in each pipe. The k-values for each pipe are given in the figure. Use Hardy Cross method. (8)

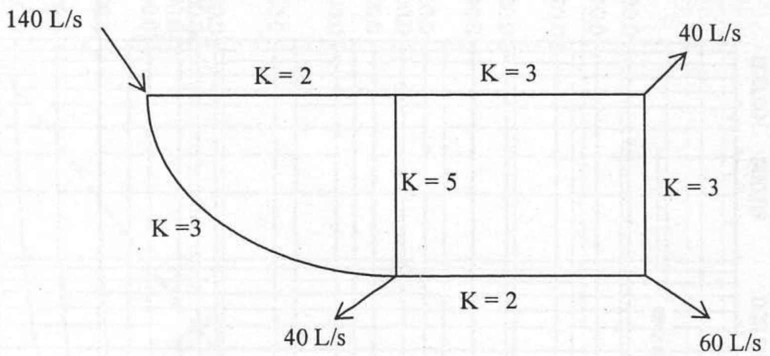

Figure 5

7. (a) Explain Reynolds experiment to distinguish between laminar and turbulent flow with a sketch. Also define critical Reynolds number. (6+4=10)

(b) A pipeline with a pump leads to a nozzle as shown in figure 6. Find the flow rate when the pump develops a head of 24 m. Assume that the head loss in the 15-cm diameter pipe may be expressed by $h_L = 5V_1^2/2g$, while the head loss in the 10-cm diameter pipe is $h_L = 12V_2^2/2g$. Sketch the energy line and the HGL, and find the pressure head at the suction side of the pump. (15)

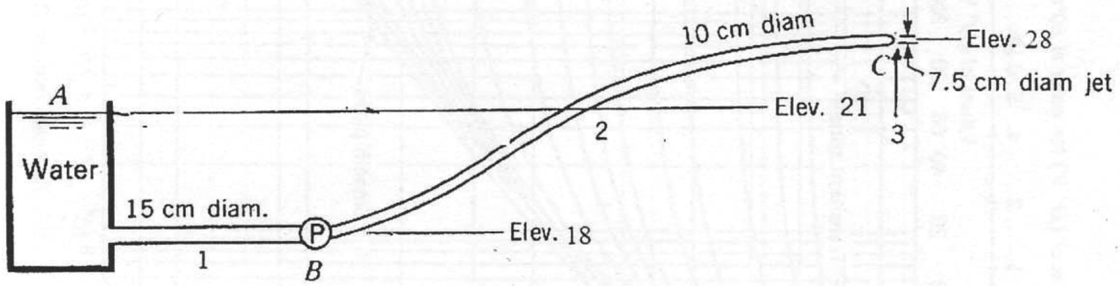

Figure 6

8. (a) Write short note on the following items:
   i. Coefficient of contraction
   ii. Head loss in orifice
   iii. Hydraulically smooth boundary. (3X3=9)

(b) What do you mean by dynamic similarity? State the use of dimensional analysis in fluid mechanics. (4+5=9)

(c) Prove that theoretical discharge through a venturimeter is given by

$$Q_t = \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}}\sqrt{2gh} \qquad (7)$$

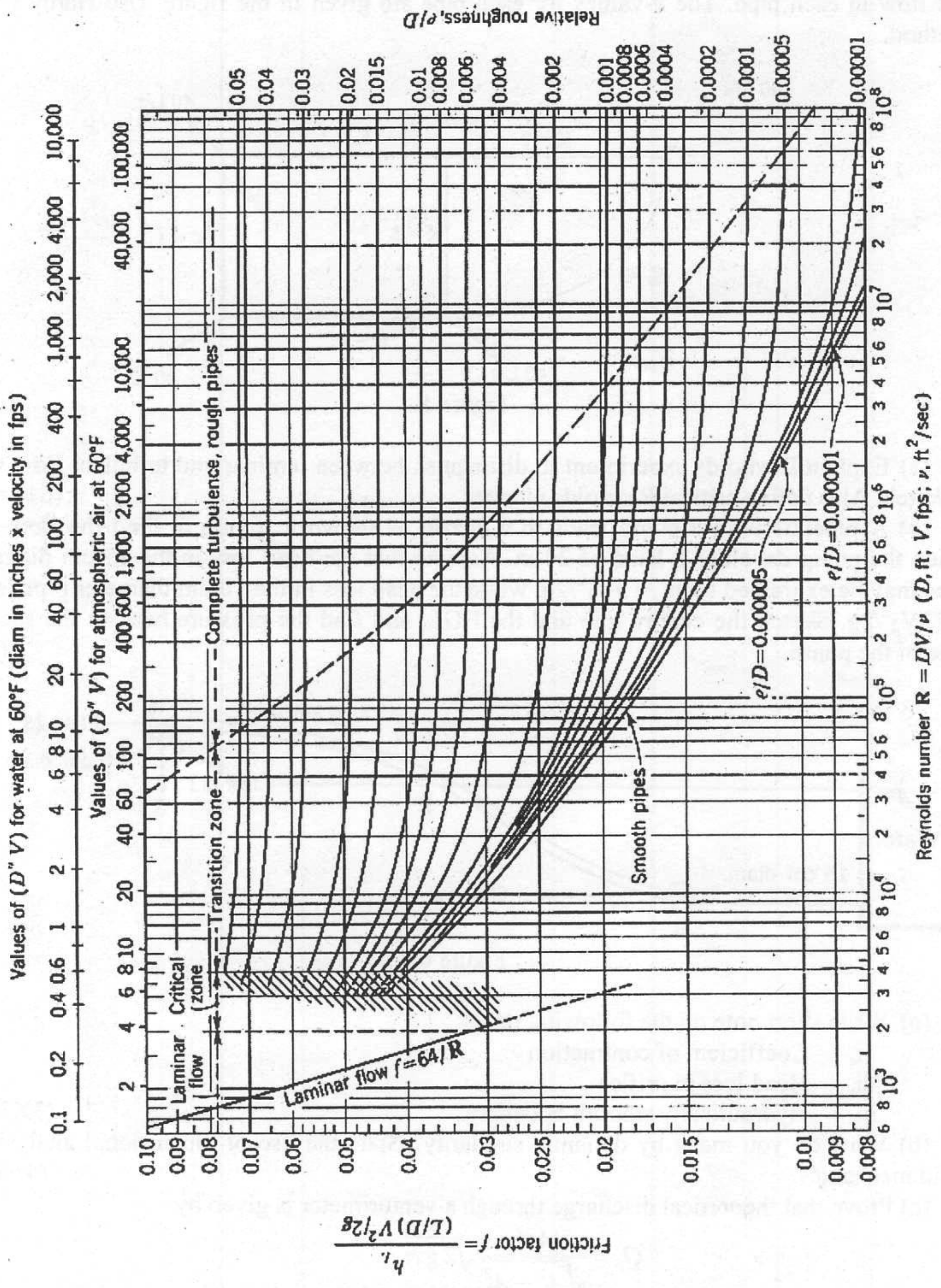

Figure 7: friction factor for pipes (Moody Diagram)

University of Asia Pacific
Department of Civil Engineering
Final Examination Spring 2013
Program: B. Sc. Engineering (Civil)

Sec. (A)

Course Title: Fluid Mechanics I	Credit Hours: 3.0	Course Code: CE 221
Time: 3 hours		Full Marks: 100 (= 5 × 20)

[Answer **any 5 (five)** of the following 7 (seven) questions. Assume any reasonable data for missing values.]

1 (a) Derive the Bernoulli's equation for incompressible fluid flow. (8)

(b) Find the total force acting on the gate per m length, which is a quadrant of a circle of radius 4 m (as shown in Figure 1). At what angle will it be acting to the horizontal? (7)

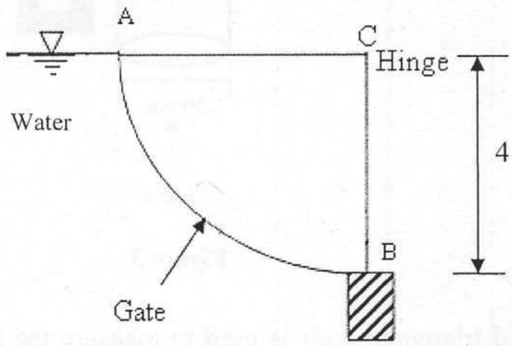

Figure 1

(c) Define "Absolute Pressure." Calculate the pressure difference between point A and B of Figure 2. Given specific weight of water is 9.81 KN/m^3 . (1+4 =5)

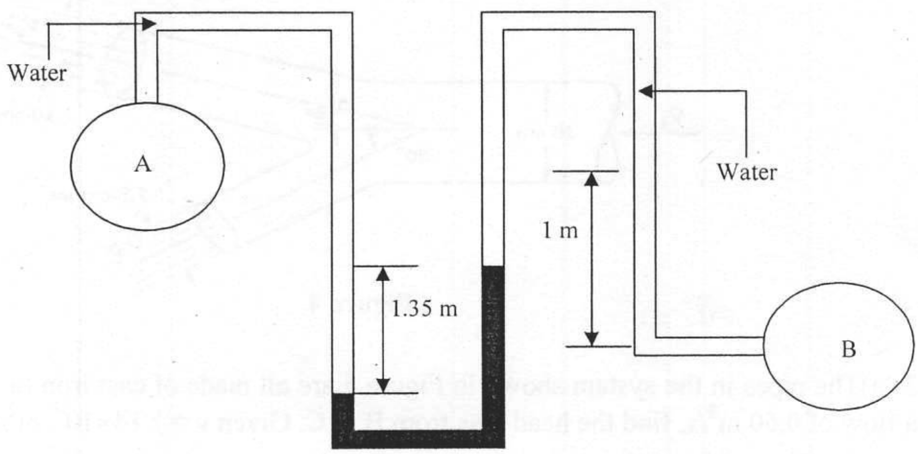

Figure 2

2.(a) Water flows in a tapered pipe as shown in Figure 3.Determine the magnitude of deflection " h" of differential mercury manometer corresponding to a discharge of 0.150 m^3/s .The friction in the pipe may be neglected and specific gravity of mercury is 13.6. (7)

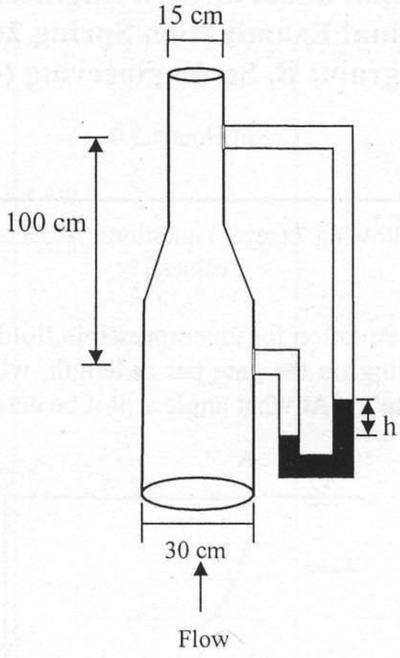

Figure 3

(b) A right-angled triangular weir is used to measure the discharge in an open channel .If the depth of water is 15 cm calculate the discharge over the weir. Assume $C_d = 0.62$. (2)

(c) Determine the magnitude and direction of the resultant force exerted on the double nozzle as shown in Figure 4. Both nozzle jets have a velocity of 24 m/s. The axis of the pipe and both nozzles lie in a horizontal plane, $\gamma = 9.81$ kN/m^3. Neglect friction. (11)

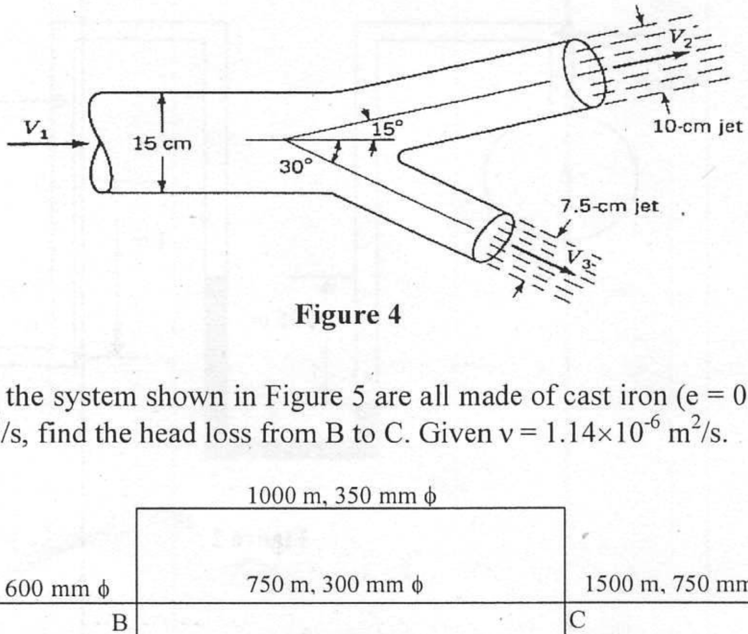

Figure 4

3.(a)The pipes in the system shown in Figure 5 are all made of cast iron (e = 0.25 mm). With a flow of 0.60 m^3/s, find the head loss from B to C. Given $\nu = 1.14\times10^{-6}$ m^2/s. (15)

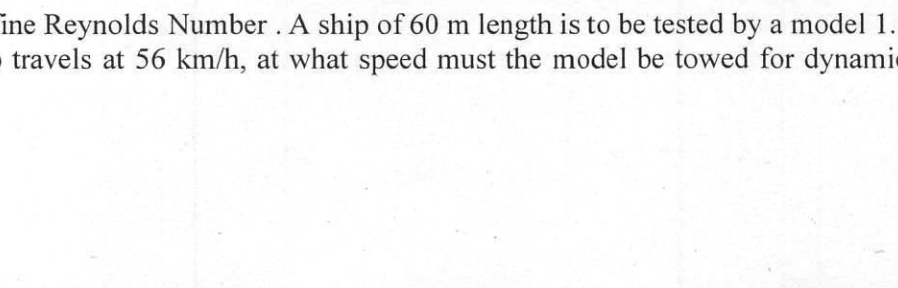

Figure 5

(b). Define Reynolds Number . A ship of 60 m length is to be tested by a model 1.5 m long. If the ship travels at 56 km/h, at what speed must the model be towed for dynamic similitude between model and prototype? If the drag of the model is 4.5 N, what prototype drag is to be expected? (1+4=5)

4.(a)Water flows into and out of a two-loop pipe system as shown in Figure 6. Determine the flow in each pipe. The k-values for each pipe are given in the figure. Use Hardy Cross method. (10)

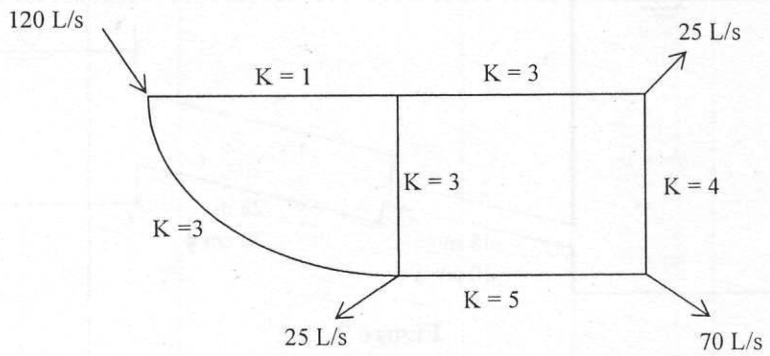

Figure 6

(b) Calculate the Kinetic Energy Correction factor for the following velocity distribution in a circular pipe of radius r_o (10)

$$\frac{u}{u_m} - \left[1 - \left(\frac{r}{r_o}\right)^2\right]$$

5.(a) A nozzle at the end of a pipe (Figure 7) discharges oil (S = 0.8) from a tank to atmosphere. Estimate the discharge from the nozzle when the head H in the tank is 4.0 m. The loss in the pipe can be taken as $20V_1^2/2g$, where V_1 = velocity in the pipe. The loss of energy in the nozzle can be assumed to be $0.11V_2^2/2g$, where V_2 = velocity in the nozzle. Also determine the pressure at the base of the nozzle. (13)

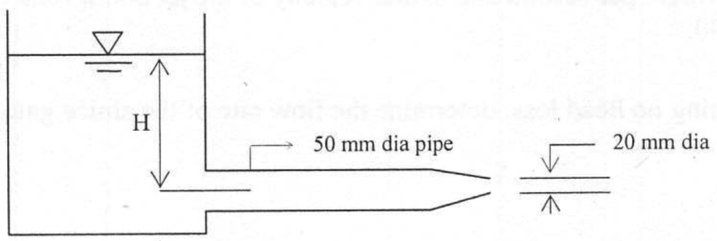

Figure 7

(b). The diameter of a tube is 0.3 m as shown in Figure 8. Determine the velocity of water leaving at C as free jet .Also determine the pressures of water in the tube at B and A. Given , specific weight of water is 9.81 KN/m^3 (7)

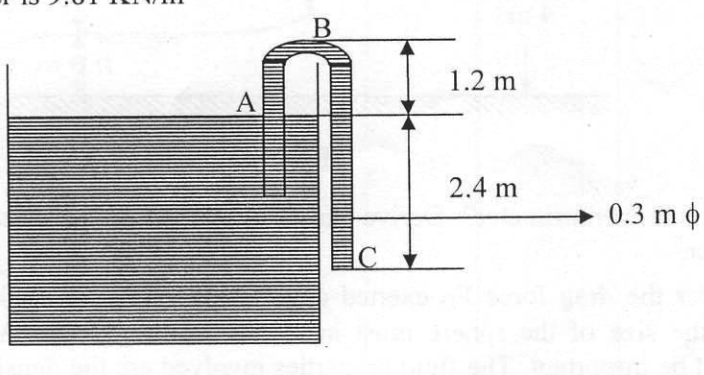

Figure 8

6.(a) Two reservoirs with a difference in water surface elevation of 8 m are connected by a pipeline which consists of two pipes 1 and 2 joined in series as shown in Figure 9. Pipe 1 is 10 cm in diameter, 18 m long and has a value of friction factor f = 0.02. Pipe 2 is of 20 cm diameter, 26 m long and has an f = 0.018. The junctions with the reservoirs and between the pipes are abrupt. Include all the minor losses. Calculate discharge. (8)

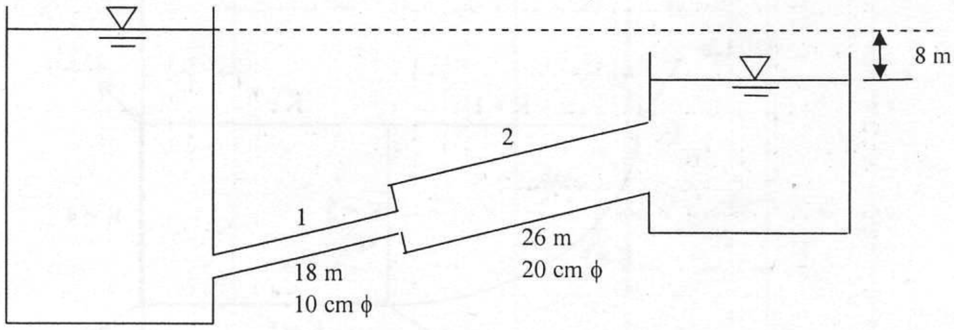

Figure 9

(b) Flow occurs over a spillway of constant section as shown in Figure 10 .Determine the horizontal force on the spillway per foot of spillway width.

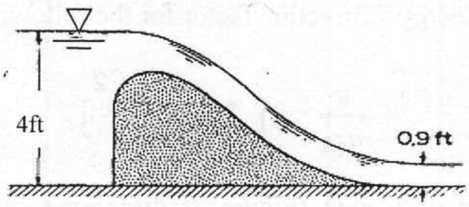

Figure 10

(c) A 60 mm diameter orifice is discharging water under a head of 9 m. Calculate the actual discharge in liters per second and actual velocity of the jet at the vena contracta, if $C_d = 0.62$ and $C_v = 0.90$. (5)

7.(a) Assuming no head loss, determine the flow rate of the sluice gate as shown in Figure 11. (6)

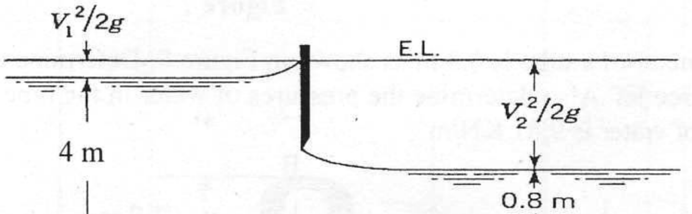

Figure 11

(b) What is a venturimeter? Derive an expression for theoretical discharge through a venturimeter. (6)

(c) Consider the drag force F_D exerted on a sphere as it moves through a viscous liquid. Certainly, the size of the sphere must influence the drag force. Also, the velocity of the sphere must be important. The fluid properties involved are the density ρ and the viscosity μ. Derive an expression for the drag force on the sphere by Rayleigh Method. (8)

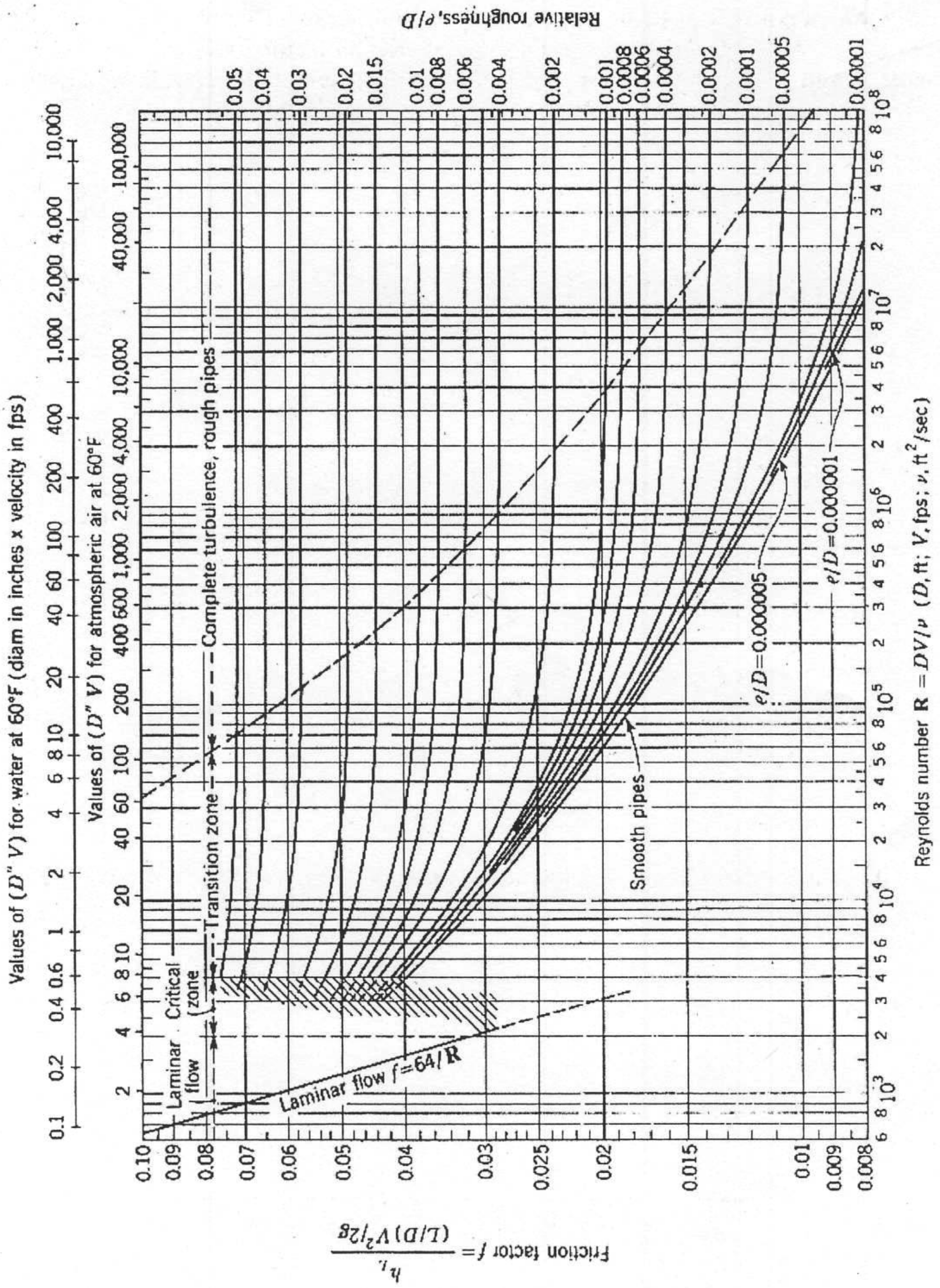

Figure: friction factor for pipes (Moody Diagram)