University of Asia Pacific
Department of Civil Engineering
Final Examination Fall 2012

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. 4** as compulsory and **any five** from the rest.

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1. (a) Write short note (any two): (2X3=6)
   i. Stream function
   ii. Flow net
   iii. Stagnation point.

   (b) Write down the equation of a streamline in 3D flow. State three characteristics of a streamline. (3+6=9)

   (c) The velocity potential for a 2D flow is given by the expression $\phi = x^2 - y^2$. Determine the velocity components, stream function and flow rate between the streamlines passing through A (1,1) and B (1,2). (10)

2. (a) Explain why a correction factor is applied while calculating the kinetic energy of fluid flow. (4)

   (b) Derive the general equation of continuity for flow through pipes. Reduce the equation for steady incompressible flow. (10+2=12)

   (c) A pipe AB (figure 1) is of uniform diameter. The pressure at A is 170 kN/m^2 and at B is 280 kN/m^2. If a crude oil (S = 0.90) is flowing through the pipe, determine the direction of flow and head loss. (9)

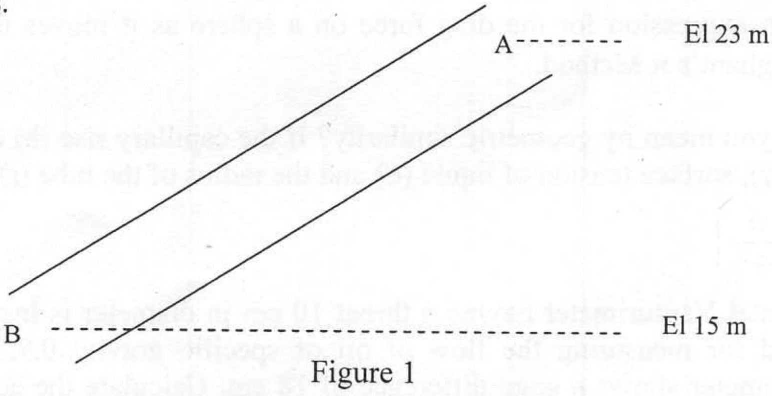

Figure 1

3. (a) Write down the impulse-momentum equation in three directions. Also state the relations between absolute and relative velocities with a neat sketch. (3+6=9)

   (b) A nozzle at the end of a pipe (figure 2) 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. (16)

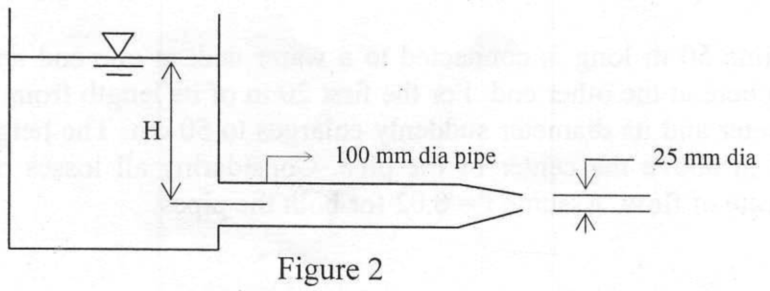

Figure 2

4. (a) Define Cavitation. Write down the necessary condition for cavitation to occur in pipe flow. What measures should be taken to avoid such problem? (3+3+3=9)

(b) A curved pipe section of length 10 m that is attached to the straight pipe section as shown in figure 3. 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 $\gamma = 8.80\ kN/m^3$. (16)

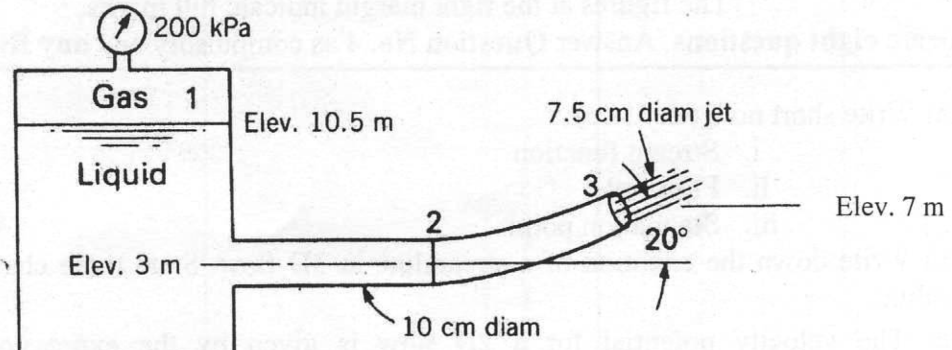

Figure 3

5. (a) A Centrifugal Pump Impeller has $r_1 = 0.3$ m, $r_2 = 1.0$ m, $\beta_1 = 120^0$, $\beta_2 = 135^0$, and thickness of 0.1 m parallel to the axis of rotation. If it delivers 2.50 m^3/s with no tangential velocity component at the entrance (i.e. radial flow pump), what is the rotational speed? For this condition calculate:

i. Torque
ii. Power of the machine
iii. Energy given to each Newton of water. (15)

(b) Derive an expression for the drag force on a sphere as it moves through a viscous liquid by Buckingham's π Method. (10)

6. (a) What do you mean by geometric similarity? If the capillary rise (h) depends upon the specific weight (γ), surface tension of liquid (σ) and the radius of the tube (r), show that

$$h = r.f\left(\frac{\sigma}{\gamma r^2}\right)$$ (2+7=9)

(b) A horizontal Venturimeter having a throat 10 cm in diameter is installed in a 30 cm pipe and is used for measuring the flow of oil of specific gravity 0.9. The oil-mercury differential manometer shows a gage difference of 18 cm. Calculate the actual discharge in liters per second if the meter coefficient is 0.98. Given, (10)

$$Q_a = \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \sqrt{2gh}$$

(c) Write short note: (2X3=6)

i. Hydraulically rough boundary
ii. Viscous sublayer in turbulent flow

7. (a) A pipeline 50 m long is connected to a water tank at one end and discharges freely into the atmosphere at the other end. For the first 20 m of its length from the tank, the pipe is 25 cm in diameter and its diameter suddenly enlarges to 50 cm. The height of water level in the tank is 10 m above the center of the pipe. Considering all losses of head that occurs, determine the rate of flow. Assume f = 0.02 for both the pipes. (8)

(b) Two reservoirs with a difference in water surface elevation of 8 m are connected by two pipes in series as shown in figure 4. The equivalent roughness heights of the two pipes are 2.0 and 0.3 mm respectively. Find discharge by equivalent velocity head method. Given $\nu = 3\times10^{-6}$ m^2/s. Use Moody diagram for friction factor. (17)

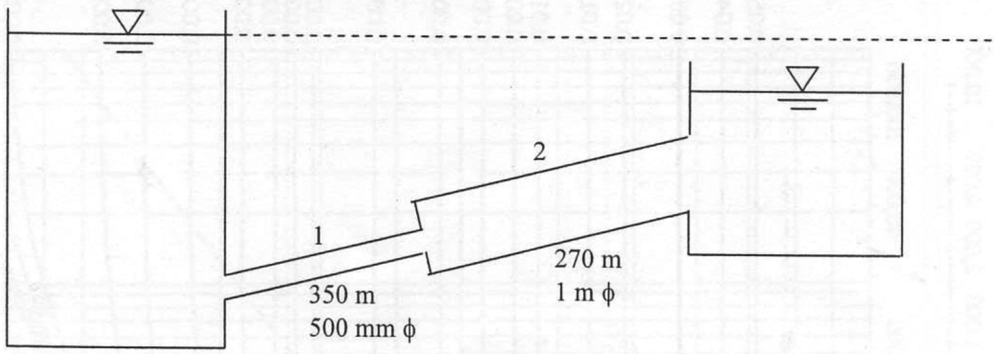

Figure 4

8. (a) The pipes in the system shown in figure 5 are all new cast iron (e = 0.25 mm). With a flow of 0.70 m^3/s, find the head loss from B to C. Given $\nu = 1.14\times10^{-6}$ m^2/s. (15)

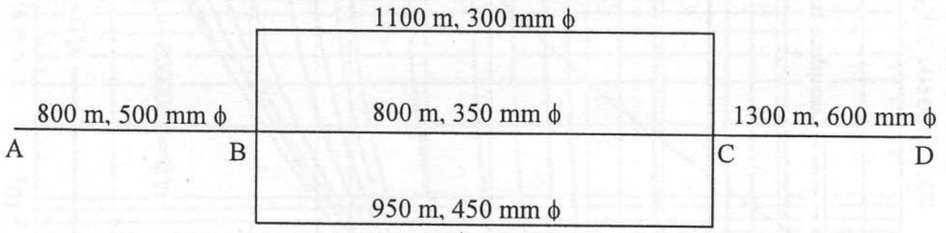

Figure 5

(b) If the flows into and out of a two-loop pipe system are 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)

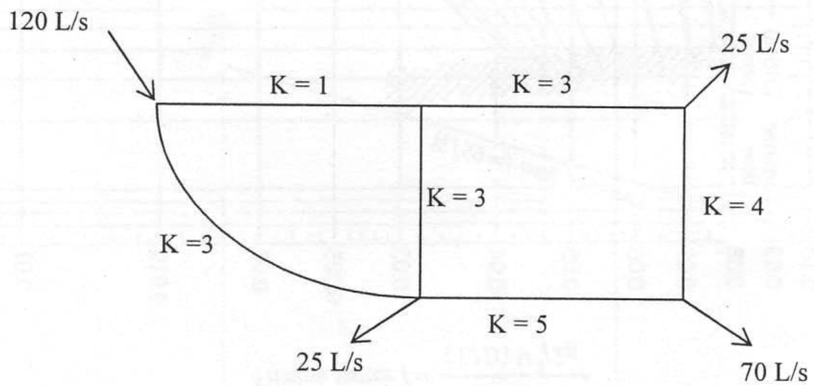

Figure 6

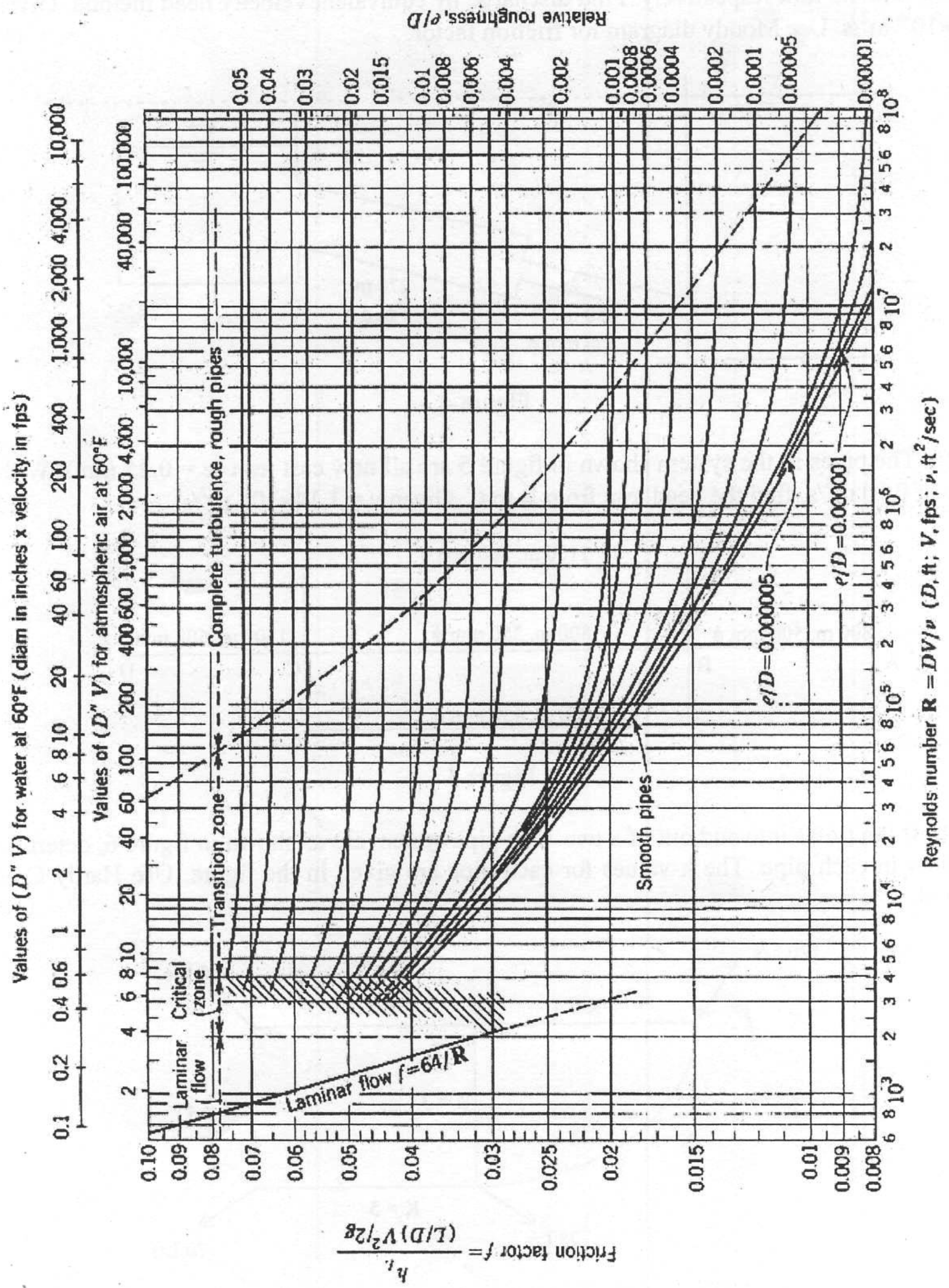

Figure7: friction factor for pipes (Moody Diagram)