**Note: Assume any data required, state your assumption clearly.**

## Question (1)                                        (20 Marks)

1.a) Discus the types of losses in pipelines  (3 Marks)

1.b) A pipeline 10 km long, 300 mm diameter and with roughness 0.03 mm, conveys water from a reservoir (top water level 850 m) to a water treatment plant (elevation 700 m). Assuming that the reservoir remains full, and neglecting minor losses, estimate the quantity of flow. Take ($\mu$= 1.307× 10$^{-3}$ Pa.s, $\rho$'=1000 kg/m$^3$)

**(7 Marks)**

1-c) Petrol of kinematic viscosity 0.6 mm$^2$/s is to be pumped at the rate of 0.8 m$^3$/s through a horizontal pipe of 500 mm diameter. However, to reduce pumping costs a pipe of different diameter is suggested. Assuming that the absolute roughness of the walls would be the same for a pipe of slightly different diameter, and that, for $Re$ > 106, $f$ is approximately proportional to the cube root of the relative roughness, determine the diameter of pipe for which the pumping costs would be halved.

**(10 Marks)**

## Question (2)                                        (20 Marks)

2.a) drive an expression for head loss in perforated pipe with constant draw off and constant friction factor. **(5 Marks)**

2.b) Reservoirs A, B and C have constant water levels of 150, 120 and 90 m respectively above datum and are connected by pipes to a single junction J at elevation 125 m. The loss coefficient ($k$) of each pipe are given below based on $h_l = kQ^2$ are 1224, 7488 and 6134 respectively. Calculate the flow rate in each pipe and the pressure reading the junction J. Now it is required to duplicate the flow rate to the lowest reservoir by installing a poster pump in the pipe connecting the highest reservoir. Calculate the power supplied by the pump. Take specific weight of water as 10$^4$ N/m$^3$.  **(15 Marks)**

## Question (3)                                        (20 Marks)

3.a) Dive an expression for head rise coefficient due to lateral outlet and discuss how it changes with $Q_3/Q_1$.

3.b) The 3-port manifold shown in the next diagram has a port-to-main diameter ratio $D_3/D_1$ = 0.5, a friction factor $f$ = 0.02 in the main and all laterals, and $L_3/D_3$ = 2 for each lateral. Considering fluid friction in the main and laterals and junction losses, compute the port discharges $Q_a$, $Q_b$, and $Q_c$. The downstream end of the main is closed off by a blank plate. **(15 Marks)**

15 m

1 m | 1 m
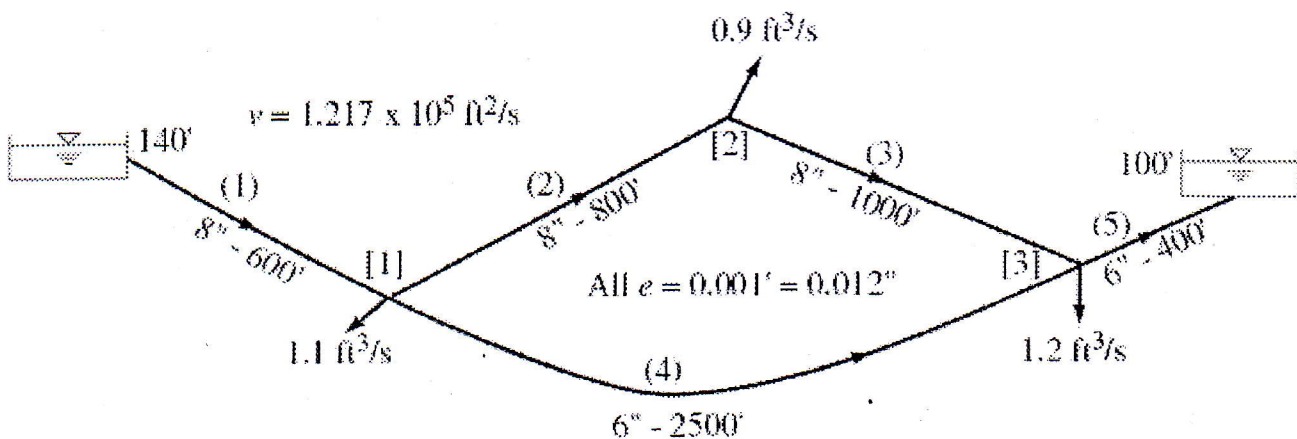
$H_R = $ 8 m

$D_m = $ 10 cm

$Q_c$  $Q_b$  $Q_a$
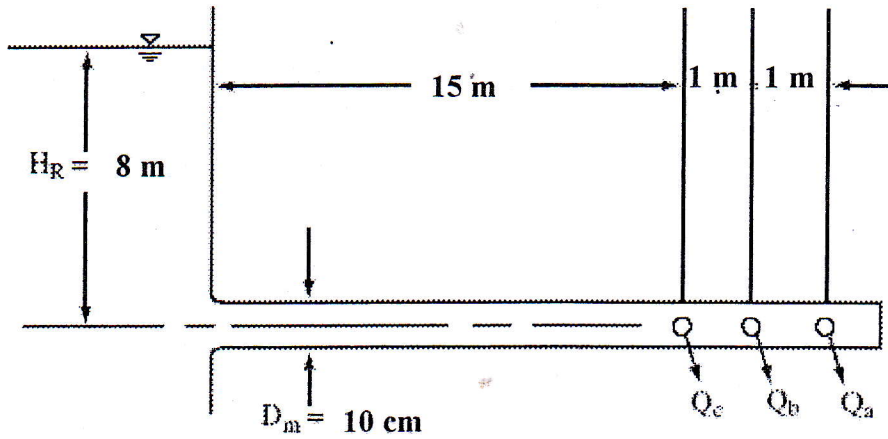
## Question (4)  (25 Marks)

4.a) In the figure below all four horizontal cast-iron (f = 0.02) pipes are 45 m long and 8 cm in diameter and meet at junction a, delivering water at 20°C($\mu$= 1.307× $10^{-3}$ Pa.s, $\rho$ =1000 kg/m$^3$). The pressures are known at four points as shown: $p_1$ = 950 kPa, $p_2$ = 350 kPa, $p_3$ = 675 kPa, $p_4$ = 100 kPa. Neglecting minor losses, determine the flow rate and direction in each pipe. **(10 Marks)** ●
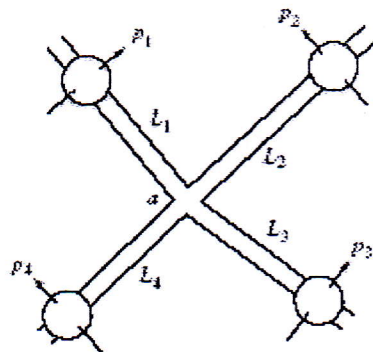


4.b) A 5-pipe, 3-node network appears below. On this diagram the first number along each line is the pipe diameter in inches, and the second number is the pipe length in feet. Do the following tasks: (a) write the system of Q-equations; (b) write the system of $\Delta Q$-equations; (c) using the Newton method, describe the solution of the system of $\Delta Q$-equations. **(15 Marks)** ●



0.9 ft$^3$/s

$v = 1.217$ x $10^5$ ft$^2$/s

140'

(1)

8"-600'

[1]

1.1 ft$^3$/s

(2)

8"-800'

[2]

8"-1000'

(3)

All e = 0.001' = 0.012"

(4)

6" - 2500'

100'

(5)

6"-400'

[3]

1.2 ft$^3$/s

**GOOD LUCK**