M.E. (Water Resources & Hydraulic Engineering) Exam. (Evening), 2018

(Second Year-2nd Semester)

DESIGN OF WATER RESOURCES SYSTEM

Time : Three Hours Full Marks : 100

Answer any ***four*** questions.

1. (a) Derive the following expression of the velocity of propagation of the pressure wave (C) for the water hammer in case of an elastic pipe.

$$C = \sqrt{\frac{\frac{K}{\rho}}{1+\frac{K}{E}\frac{d}{t}}}$$

where, K is the bulk modulus of elasticity, ρ is the density of water, E is Young's modulus of elasticity, d is the pipe internal diameter and t is the pipe wall thickness. Assume that the pipe is subjected to circumferential stress but negligible longitudinal stress.

Then derive a relationship between maximum water hammer head (h_m) and static head (h_{static}).

(b) Differentiate between slow closure, rapid closure, gradual closure and instantaneous closure.

(c) A steel pipeline [roughness (ε) = 0.046] 61 cm diameter and 3220 m long discharges freely at its lower end under a head (h) of 61 m. What water hammer pressure would develop if a valve at the outlet were closed in 4 sec? 60 sec?

(i) Wall thickness of the pipeline is 5 mm for both case of closure. Compute the stress that would develop the walls of the pipe near the valve.

(ii) If the working stress is taken as 1.1×10^8 N/m^2, what would be the minimum time of safe closure?

The bulk modulus of elasticity of water is 2.17×10^9 N/m^2, Young's modulus of elasticity for the pipe material 1.9×10^{11} N/m^2, kinematic viscosity (v) of water 1.14×10^{-6} m^2/s and density of water is 1000 kg/m^3. Assume proper notations, if required.

10+3+12=25

2. (a) Briefly highlight salient information on arsenic contamination of groundwater in West Bengal.

(b) Suggest measures to be taken to mitigation the arsenic problem.
(c) An arsenic removal unit (ARU) is proposed to be attached with a tube well for supply of arsenic safe water to the village community.

- Village population-2400; Per capita water supply for drinking and cooking- 10 lts/day
- The proposed ARU will be operated for 12 hrs a day.

(i) Design the Arsenic Removal Unit.
(ii) Draw Plan of the Proposed ARU.
(iii) Draw hydraulic flow diagram of ARU

4+4+17=25

3. (a) The pipe system shown in fig. below connects two reservoirs that have an elevation difference of 20 m. This pipe system consists of 200 m of 500 mm concrete pipe–A, that branches into 400 m of 200 mm pipe-B and 400 m of 400 mm pipe-C in parallel. Pipes B and C join into a single 500 mm pipe that is 500 m long pipe-D. For f = 0.030 in all pipes, what is the flow rate in each pipe of the system?

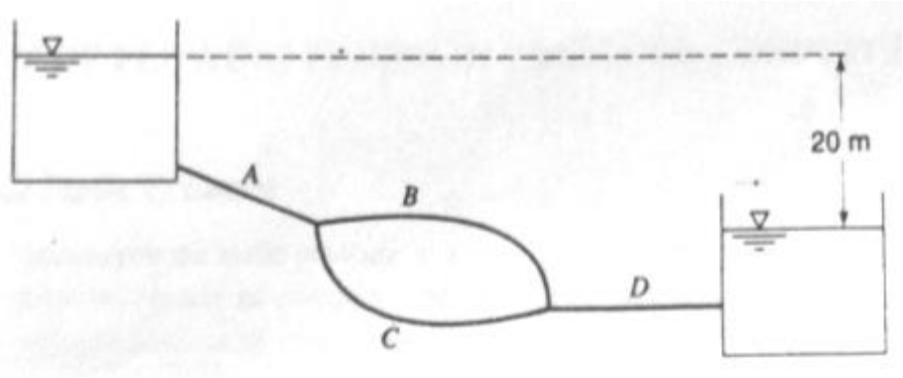


Fig. Pipe system

(b) Using Buckingham pi theorem, establish a relation between three dimensionless groups such as head co-efficient, flow co-efficeint and Reynolds number. What is Affinity law?

15+10=25

4. (a) Water at 20^0C is being pumped from a lower to an upper reservoir through a 200 mm pipe in the system. The water surface elevations in the source and destination reservoirs differ by 5.2 m, and the length of the steel pipe connecting the reservoirs is 21.3 m. The pump is to be located 1.5 m above the water surface in the source reservoir, and the length of the pipeline between the source reservoir and the suction side of the pump is 3.5 m. Express the head loss due to pipe friction in terms of flow rate. The performance curves of the 885 rpm homologous series of pumps being considered for this system are given below. Assume f = 0.040 and neglecting local head losses.

Q (m^3/s)	h_p (m)	η (%)	Q (m^3/s)	h_p (m)	η (%)	Q (m^3/s)	h_p (m)	η (%)

0	10	0	0.18	12	30	0.214	13.5	55
0.245	12.5	76	0.277	13.5	70	0.305	8.5	70
0.345	6.5	57	0.370	4.5	38			

(i) Estimate the operating point of Q and h_p from the pump-system characteristics curve.

(ii) Estimate the brake Horsepower (BHP) to be required in the pipeline system.

(iii) What specific-speed pump should be selected at the operating point condition?

(iv) Estimate the available net positive suction head at the operating point condition. Assume atmospheric pressure = 101 kPa; saturated vapour pressure of water =2.34 kPa; specific weight of water =9.80 kN/m^3. 13+4+4+4 =25

5. (a) Design a trapezoidal drainage channel to accommodate a peak flow rate of 1.5 m^3/s on a slope of 0.65%. Local regulations require that the side slope of the channel be no greater than 3:1 (H : V). A filed investigation has indicated that the native soil is non-cohesive and has a 50-perentile grain size of 50 mm. Use gravel mulch lining. Assume n = 0.022 and the permissible shear stress on the gravel mulch lining = 28 Pa. Assume angle of repose = 36.8^0

(b) Differentiate between cohesive and non-cohesive materials. Using Buckingham pi theorem, establish a relation between the critical shear stress (τc) and shear velocity (u*).on non-cohesive bottom sediments.

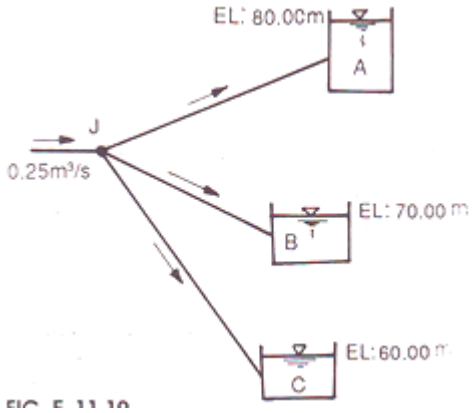
15+10=25

6. (a) Show the energy grade line through manholes with equations to avoid backwater effects.

(b) A fully developed 55 km^2 city will have land uses that are 70% residential, 20% commercial, and 10% industrial. The residential development will be 20% large lots (6 persons/ha), 70% small single-family lots (75 persons/ha), and 10% multistory apartments (2500 persons/ha). The average wastewater flow rates can be taken as 168 L/d/person for large and single family lots, 150 L/d/person for apartments, the average commercial flow rate as 50,000 l/d/ha, and the average industrial flow rate as 90,000 L/d/ha. When the sewer is first installed, the average wastewater flow rate will be 30% of the average flow rate expected when the area is fully developed. Infiltration and inflow is estimated 1600 L/d/ha for the entire area. Estimate the maximum and minimum flow rates to be handled by the main sewer.

(c) What are the components of flows in sanitary sewers and discuss them with their empirical equations. 5+14+6 = 25

7. (a) A Water Supply main trifurcates at a junction point J into three branches each feeding a separate reservoir. The details of the pipes and the reservoir are as follows:

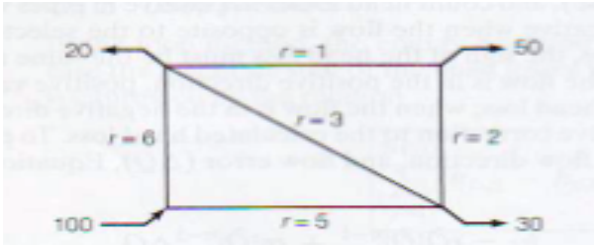


Pipe	Diameter (mm)	Length (m)	f	Feeding to reservoir elevation (m)
JA	200	2000	0.02	A=80
JB	300	2500	0.03	B=70
JC	400	3000	0.04	C=60

If the inflow from the main at the junction is 0.250 m^3/s, determine the delivery into each reservoir.

(b) State the difference between $NPSH_A$ and $NPSH_R$

(c) A pipe network is shown in figure given below in which Q and h_f refers to a discharge and head losses respectively. Determine the head losses and discharges for this pipe network. The head loss h_f is given by $h_f = rQ^2$. Consider correction to be done up to second trial. Assume f= 0.03. All dimensions are in SI unit.



12+3+10=25