M.E. (Water Resources & Hydraulic Engineering) Exam., 2019
(1[st] Year-2[nd] Semester)

DESIGN OF WATER RESOURCES SYSTEM

PAPER-IX

Time : Three Hours

Full Marks : 100

Answer any ***four*** questions.

1. (a) Derive an expression of the velocity of propagation of the pressure wave for the water hammer in case of an rigid pipe where the pipe is subjected to circumferential stress but negligible longitudinal stress. Assume proper notations.

   (b) What do you mean by "Surge Tank"? Classify different types of surge tank. Explain their operating principles with neat sketches.

   (c) What is flowing at 3.2 m/s in a pressure penstock 4500 m long. If the celerity of the pressure wave travelling in the pipe due to the sudden complete closure of a valve at the downstream end is given as 1450 m/s, what is the maximum pressure rise? What is the period of oscillation? Show how the pressure changes with time at the middle point of the penstock length. Ignore all frictional losses

10+8+7=25

2. (a) Discus the differences in approaches to designing water resources systems.

   b) An existing well field consists of four wells at the corners of a rectangular area 100 m long by 75 m wide. Each well has a design capacity of 467 lps and the observed drawdown in the center of the rectangular area is 2 m when all wells are pumping at their capacity. The specific yield of the aquifer is estimated as 0.2. Consideration is being given to the addition of a fifth well to the well field such that the new well is no more than 75m from any of the existing wells, and the drawdown in the center of the rectangular area is not to exceed the current maximum value of 2m. Taking the pumping capacity of all wells in the expanded well field to be the same, determine the increase in total pumping capacity of the well field that can be achieved.

3+22=25

3. (a) 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?

   (b) A pump is placed in a pipe system in which the energy equation (system curve) is given by

$$h_p = 15 + 0.03Q^2$$

where h_p is the head added by the pump in meters and Q is the flow rate through the system in L/s. The performance curve of the pump is

$$h_p = 20 - 0.08Q^2$$

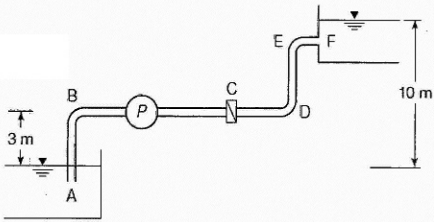
What is the flow rate through the system? If the pump is replaced by two identical pumps in parallel, what would be the flow rate in the system? If the pump is replaced by two identical pumps in series, what would be the flow rate in the system?

10+15=25

4. Water is being pumped from reservoir A to reservoir F through a 30-m long PVC pipe of diameter 150 mm (see Figure). There is an open gate valve located at C; 90^0bends (threaded) located at B, D, and E; and the pump performance curve is given by

$$h_p = 20 - 4713Q^2$$

where h_p is the head added by the pump in meters and Q is the flow rate in m^3/s. The specific speed of the pump is 3000. Assuming that the flow is turbulent (in the smooth, rough, or transition range) and the temperature of the water is 20^0C, (a) write the energy equation between the upper and lower reservoirs, accounting for entrance, exit, and local losses between A and F; (b) calculate the flow rate and velocity in the pipe; (c) if the required net positive suction head at the pump operating point is 3.0 m, assess the potential for cavitation in the pump (for this analysis you may assume that the head loss in the pipe is negligible between the intake and the pump); and (d) use the affinity laws to estimate the pump performance curve when the motor on the pump is changed from 800 rpm to 1600 rpm. Assume f= 0.014; p_0 (atmospheric pressure) = 101 kPa, γ*(specific wt.)* = 9.79 kN/m^3, p_v *(vapour pressure)* = 2.34 kPa (at 20^0C). Assume loss coefficients K_A=K_F=1.0; K_B= K_D= K_E= 0.9; K_C =0.2



10+4+6+5 =25

5. (a) Design the most efficient (straight) lined trapezoidal channel to carry 30 m^3/s on a longitudinal slope of 0.002. The lining of the channel is to be float-finished concrete. Assume n= 0.015.

(b) A trapezoidal channel has a design peak flow rate of 0.42 m^3/s, a bottom width of 0.4 m, side slopes of 3:1, and a longitudinal slope of 0.8%. If an open-graded gravel mulch lining is to be used, check the adequacy of median stone size for the lining. Try gravel mulch lining with d_{50} = 50 mm; Assume n = 0.022 and the permissible shear stress on the gravel mulch lining = 38 Pa. Assume angle of repose = 35.4^0

10+15=25

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

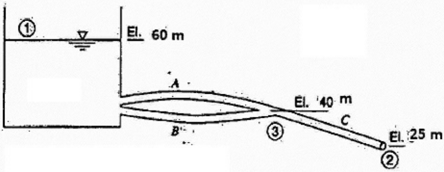
(b) Water flows at a rate of 7 m^3/s in a circular concrete sewer of diameter 1600 mm. If the slope of the sewer is 0.01, estimate the depth of flow and velocity in the sewer. What diameter of pipe would be required for the pipe to flow three-quarters full? Assume n= 0.013.

(c) What are the components of flows in sanitary sewers and discuss them with their empirical equations. 5+12+8 = 25

7. (a) The three-pipe system shown in Fig. below has the following characteristics:

Pipe	Elevation (m)	Pipe length (m)	Diameter (mm)	Friction factor (f)
A	60	450	200	0.020
B	40	600	150	0.025
C	25	900	250	0.030

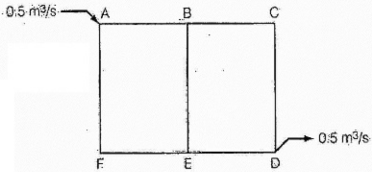
Find the flow rates of water in each pipe and the pressure at point 3. Neglect minor losses.



(b) State the difference between $NPSH_A$ and $NPSH_R$. Define Cavitation number.

(c) Consider the pipe network shown in Figure. 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. All dimensions are in SI unit. Assume f= 0.03.

Pipe	L (m)	D (mm)	Pipe	L (m)	D (mm)
AB	1000	300	BC	750	325
CD	800	200	DE	700	250
EF	900	300	FA	900	250
BE	950	350			



Figure

12+3+10=25