

**M.E. (Water Resources & Hydraulic Engineering) Exam.(Evening), 2019**  
**(Second Year-2<sup>nd</sup> Semester)**

**DESIGN OF WATER RESOURCES SYSTEM**

**Paper-X**

Time : Three Hours

Full Marks : 100

Answer any *four* questions.

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

$$C = \sqrt{\frac{\frac{K}{\rho}}{1 + \left(\frac{K d}{E t}\right) \Psi}}$$

where,  $K$  is the bulk modulus of elasticity,  $\rho$  is the density of water,  $E$  is Young's modulus of elasticity,  $d$  is the pipe internal diameter,  $t$  is the pipe wall thickness and  $\Psi$  is a factor that depends on pipeline support characteristics and Poisson's ratio. 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 ( $h_{static}$ ).

- (c) A cast iron pipe with 25.4 cm diameter and 8 mm wall thickness is carrying water when the outlet is suddenly closed. Use bulk modulus of elasticity of water =  $2.17 \times 10^9$  N/m<sup>2</sup> and Young's modulus of elasticity for the pipe material is  $16 \times 10^{11}$  N/m<sup>2</sup>. If the design discharge is 50 L/s, calculate the water hammer pressure rise for: (i) rigid pipe walls, (ii) consider stretching of pipe walls, neglecting the longitudinal stress and (iii) pipeline that is anchored at the upstream end only.

2+(12+2)+9=25

2. (a) a) How do you categorize water resources systems and what are their design objectives?  
 b) Discuss the differences in approaches to designing water resources systems.  
 c) A small municipal well field is to be developed in an unconfined sand aquifer with a hydraulic conductivity of 50m/d, saturated thickness of 30m, and specific yield of 0.2. A service demand of 81 lps is required from the well field, and the diameter of each well is to be 60 cm. If the drawdown in the aquifer is not to exceed 3 m when the well field is

operational, develop a proposed layout for the wells. There are no nearby surface-water bodies.

(3+2+20)

3. (a) Using Buckingham pi theorem, establish a relation between three dimensionless groups such as head co-efficient, flow co-efficient 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

$$h_p = 20 + 0.03Q^2$$

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

$$h_p = 25 - 0.08Q^2$$

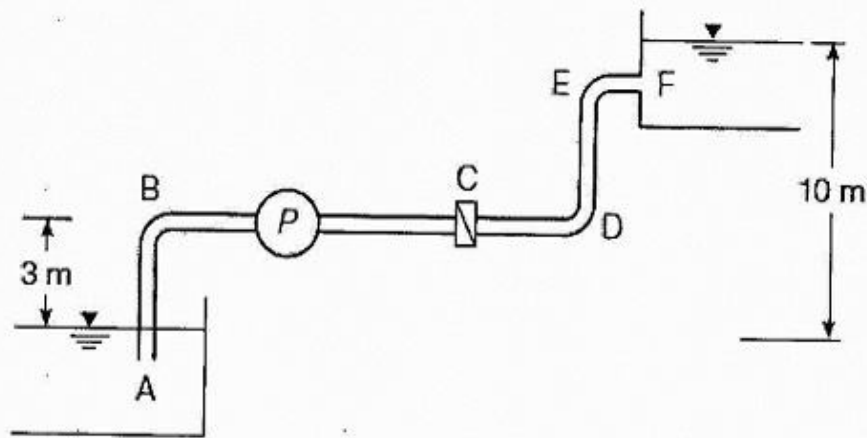
What is the flow rate through the system? If the pump is replaced by two identical pumps in parallel, what would be the flow rate in the system? If the pump is replaced by two identical pumps in series, what would be the flow rate in the system?

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° bends (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°C, (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 900 rpm to 1800 rpm. Assume  $f = 0.014$ ;  $p_0$  (atmospheric pressure) = 101 kPa,  $\gamma$  (specific wt.) = 9.79 kN/m<sup>3</sup>,  $p_v$  (vapour pressure) = 2.34 kPa (at 20°C). 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  $35 \text{ m}^3/\text{s}$  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  $0.45 \text{ m}^3/\text{s}$ , a bottom width of 0.45 m, side slopes of 3:1, and a longitudinal slope of 0.85%. 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  $d_{50} = 50 \text{ mm}$ ; Assume  $n = 0.022$  and the permissible shear stress on the gravel mulch lining = 38 Pa. Assume angle of repose =  $35.4^\circ$

$$10+15=25$$

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

(b) Water flows at a rate of  $8.5 \text{ m}^3/\text{s}$  in a circular concrete sewer of diameter 1800 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  $n = 0.013$ .

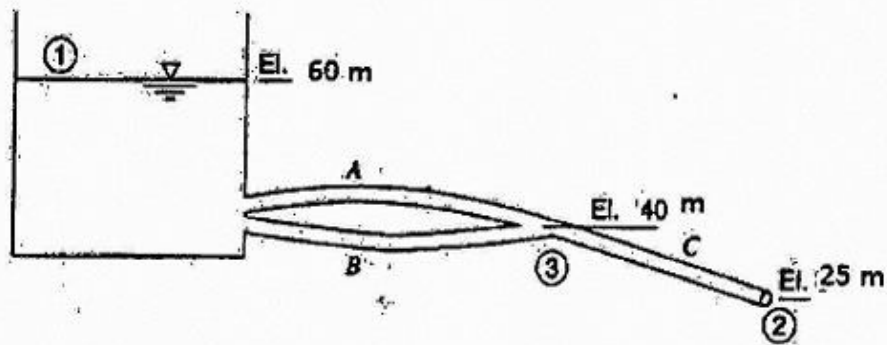
(c) What are the components of flows in sanitary sewers and discuss them with their empirical equations.

$$5+12+8 = 25$$

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

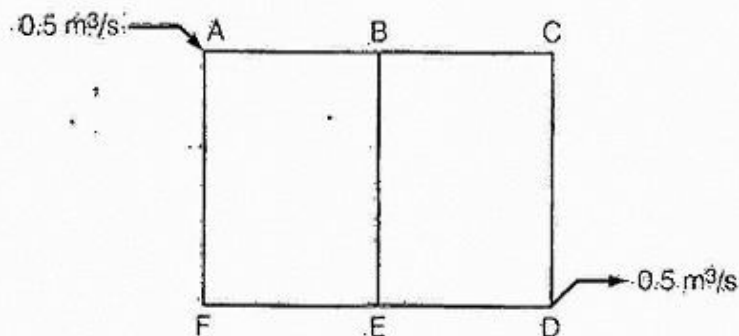
Find the flow rates of water in each pipe and the pressure at point 3. Neglect minor losses.



(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