THE OPEN UNIVERSITY OF SRI LANKA
Department of Civil Engineering
Diploma in Technology - Level 4

CEX 4234- WATER SUPPLY AND SEWERAGE ENGINEERING

FINAL EXAMINATION - 2009/2010

Time Allowed: Three Hours *Index No.* ☐☐☐☐☐

Date: 11th March, 2010 **Time: 0930 - 1230**

Answer any FIVE questions. All questions carry equal marks.

Question 1.

(a) Design period and the population forecasting are very important aspects of any water supply systems.

(i) What is meant by design period and why is it important in water supply projects? [02 marks]

(ii) People in a semi urban city are looking for pipe borne water supply system because their well water gives objectionable taste and laundry becomes tarnish in the wash. If they seek your opinion, how do you advice them to come out of this problem. Your answer should include causing factors and solutions. [03 marks]

(b) The Government plans to provide water supply system from Daduganoya to the above growing semi urban city. Suppose you are working in the above project and asked to calculate future population approximately based on the following census records. Estimate the population using the most appropriate method. [06 marks]

Year	1979	1989	1999	2009
Population	12000	16,300	22,400	31,300

(c) Intakes are used for bringing water from the surface sources to the treatment plants.

(i) What are the important considerations of selecting a site for a river intake? [02 marks]

(ii) Why do tower intakes in lakes and reservoirs have entry ports in various depths? [02 marks]

(iii) A bell mouth canal intake for a city with population of 5000 drawing water from a canal 10 hours a day. The average consumption per person is 160 liters/day. The velocity through the screens of the bell mouth is 16m/s. Estimate the discharge through intake. Assume full flow through the intake main. [03 marks]

(iv) Suppose, area of the bell mouth is covered by solid bars of 30 % of total area to remove large floating matters. Compute the effective area of the bell mouth. [02 marks]

Question 2.

(a) A water treatment plant in a city employs, two rectangular sedimentation basins, each 25m long, 5m wide and 3.8m deep, settle 6000 m^3/d of water flow. If total effluent weir length is 50m, calculate:

(i) Detention time [01 marks]
(ii) Overflow rate [02 marks]
(iii) Weir loading [02 marks]

(b) Coagulation and flocculation are usually adopted in water treatment plants.

(i) Why coagulation and flocculation are necessary in water treatment system? Explain briefly? [02 marks]
(ii) List the various types of coagulants added into the water treatment plants. What do you recommend to the water treatment systems in Sri Lanka out of them? Why? [02 marks]
(iii) What mechanism can be used for mixing coagulant with water at coagulation basin? [02 marks]
(iv) A water treatment system of a city belongs to NWS&DB (Water Board) treats 50 million liters per day. The Jar test shows the optimum dosage needed for coagulation is 15mg/l of water. Determine the required amount of coagulant per month by NWS & DB for the water treatment plant. [02 marks]

(c) Filtration is one of the most important operations in the water purification process. Rapid sand filters (RSF) and slow sand filters (SSF) are generally used for filtration in water supply systems.

(i) In the case of clogging, what are the cleaning steps of both types of filters? [02 marks]
(ii) A length of a filter unit is 8m while the width is 4m. After filtering 8000 m^3/day the filter is closed for 30 minutes for cleaning. What is the average rate of filtration? If only 97.6% of filtered water goes to storage tanks for distribution, compute the daily water usage for cleaning filters. [05 marks]

Question 3.

(a) A rural city, which is rich with groundwater sources, has population of 12,500. An estimated per capita water demand for the city is about 160 liters/day. It is needed to employ pumps for dragging ground water. The rising main (pipe) is 100 m long and of is 50cm of diameter. The motor efficiency is 85%, pump efficiency is 60%, friction factor f'=0.004 and the peak hour demand is 1.5 times average demand. The static lift of the pump is 20 meters. Friction head: $H_f = \frac{flv^2}{2gd}$ and velocity head : $H_v = \frac{v^2}{2g}$

(i) Calculate the losses in the pumping mains [03 marks]
(ii) What is the total head to the motor? [01 marks]
(iii) Compute the Break Horse Power (BHP) of the motor. The horse power of a pump is given with usual notation as $BHP = \frac{QwH}{75\eta}$ [03 marks]

(b) ABCD, which is shown in figure Q3 (b) is a part of a water distribution system proposed for a newly developing city. For planning distribution network it is needed to find equivalent pipes. Determine the theoretical diameter of a single 1000m long equivalent pipe from A to C, (Hazen William Constant; C=100 for the pipe material) [08 marks]

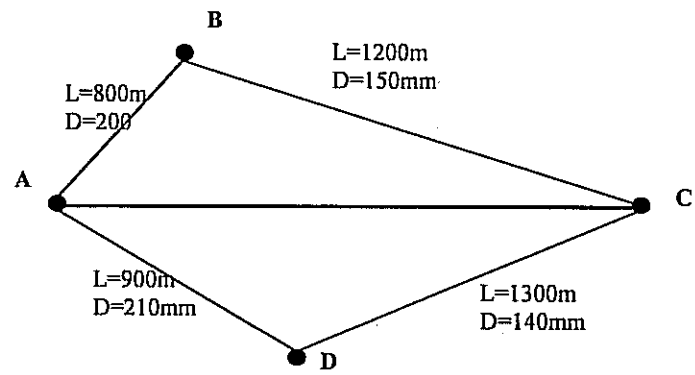


Figure Q3. Illustration for Problem Q3 (b)

(c) (i) List five materials commonly used in the manufacture of water distribution pipes. [02 marks]

(ii) Name three types of valves, which are used for distribution systems. Also mention their special characteristics in controlling water flow. [03 marks]

Question 4.

(a) Chlorination is one of the unit processes in water treatment plants.

(i) What are the advantageous of breakpoint chlorination? [02 marks]

(ii) Graphical representation of the results of chlorine demand test on raw water is given in the figure Q4 (a). Determine the break point dosage and the chlorine demand from the graph. [02 marks]

(iii) A water treatment plant carried out optimum chlorination according to the test results of chlorine demand. If the water flow is 10MLD, what would be the monthly chlorine usage? [02 marks]

(b) Most of the water sources in Sri Lanka under the threat of pollution of oxygen demanding wastes.

(i) What is meant by oxygen demanding waste? [02 marks]

(ii) Briefly explain, what is BOD_5 and COD and why is it important in relate with wastewater? [03 marks]

(iii) A treated wastewater is discharged at the rate of 1.5 m^3/sec into a river, which has minimum flow rate of 5m^3/sec. The temperature of river and wastewater is 25°C. The BOD_5 at 25°C of wastewater is 250 mg/l, and that of the river water, at upstream of the wastewater outfall is 1mg/l. If river water receives untreated wastewater, what is the BOD_5 at the mixing point? Also find the ultimate BOD_5

of the river water after it receives this wastewater. The BOD_5 removal rate constant at 20°C is $K_{20} = 0.21$/day.
[$k=k_{20}\theta^{(T-20)}$; $BOD_5 = Lo\ (1-e^{-kt})$; $\theta = 1.047$] [05 marks]

(c) (i) What are the possible problems can be arising from discharge of wastewater into coastal waters? [02 marks]

(ii) What are the important factors in locating and design of an outfall? [02 marks]

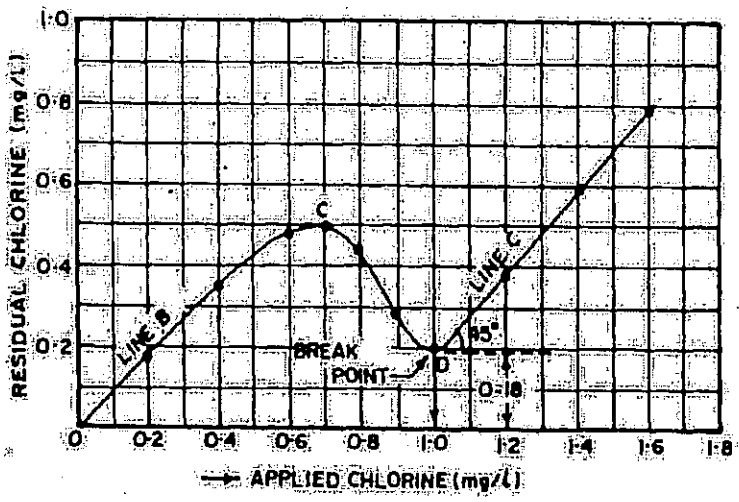


Figure Q4. Illustration for Problem Q4 (a)

Question 5.

(a) (i) Explain the term "Time of concentration" briefly. [02 marks]

(ii) Using rational formula determine the run-off for an area of 10 km^2. Rainfall related data for a given area are as follows:
Time of concentration = 20 minutes
Intensity of rain fall = 70/(T+12) cm/minute
Composite run off coefficient =0.75
Estimate the maximum rate of runoff in cubic meters per second. (Rational formula with usual notations is given as $Q = 0.278CIA$ in SI units. [04 marks]

(b) The main sewer line of the Colombo city is needed to expand in order to provide better service through wide coverage. It is designed to serve for an area of 10km^2 with the population density of 9000/Km^2. The average rate of sewage flow is 220 liters/capita/day.

(i) Compute the wastewater flow in m^2/sec? [02 marks]

(ii) If the existing wastewater flow is combined with the storm water estimated in the section Q5 (a)(ii), what would be the total design flow? [02 marks]

(iii) Compute the diameter of the proposed combined sewer section, assuming the self cleansing velocity when flowing full. [03 marks]

(c) With the new proposed sewer line, it is required to have sewer appurtenances and lift stations.

(i) Where are the junction chambers used and why? [02 marks]
(ii) What is the purpose of having inverted siphons in sewer lines? [02 marks]
(iii) In the combined sewer line a pneumatic ejector is used for lifting sewage from 10m below lift station. If the air volume is given by $V = \frac{Q(H+10.3)}{12.2}$ m^3/min, what would be the required air quantity for the ejector? [03 marks]

Question 6.

(a) Activated sludge and trickling filters with recirculation are the most common secondary treatment processes use for wastewater treatment plants.
(i) What is meant by 'recirculation' in wastewater treatment systems? Explain with the help of a sketch if necessary. [03 marks]
(ii) The flow rate of a trickling filter of a wastewater treatment plant is 4.5MLD. BOD_5 of raw sewage is 250mg/l. BOD_5 removed at the primary sedimentation tank is 25% and desired BOD_5 of final effluent is 30mg/l. Calculate the total BOD_5 in kilogram entering for the trickling filter and the BOD_5 removal efficiency of the system. [05 marks]

(b) It is proposed to design an activated sludge plant to treat 5MLD flow if domestic wastewater to reduce the concentrations of settled BOD_5 from 250mg/l to 20mg/l. If the system is to operate at F/M of 0.3/day and maintain 3000mg/l concentrations of MLSS in the aeration tank by recycling 2200m^3/day flow of activated sludge from the secondary settling tank, compute:
(i) The volume of the aeration tank [03 marks]
(ii) Hydraulic retention time [02 marks]
(iii) Oxygen required per day if the mean cell residence time is 10 days. [03 marks]
[The oxygen required/day = $1.47Q(S_o - S) - 1.42V\left(\frac{x}{\theta_c}\right)$ and $F/M = \frac{Q.BOD}{V.MLSS}$ with usual notations]

(c) (i) List the methods available for sludge thickening? [02 marks]
(ii) How do you reuse the treated wastewater? Provide two examples. [02 marks]

Question 7.

(a) In a conventional treatment plant, sludge is generated mainly from primary and secondary sedimentation tanks. Before discharge, sludge is biologically stabilized by aerobically or anaerobically.
(i) Why sludge is required to be stabilized before final disposal? [01 marks]
(ii) List the main factors that affect anaerobic sludge digestion. [02 marks]
(iii) Why mixing is important in anaerobic sludge digestion? [02 marks]

(b) Anaerobic sludge digester can be designed based on per capita volumetric loading rate. A conventional treatment plant needs to design an anaerobic digester and given data are as follows.

- Wastewater flow = $10x10^6$ L/d
- Suspended solids in wastewater = 250 mg/L
- SS removal efficiency in primary clarifier = 60%
- Volumetric loading rate = $45m^3$/1000 persons
- Solids contribution = 75 g/capita/day

Compute;

(i) Sludge produced due to SS removal [03 marks]

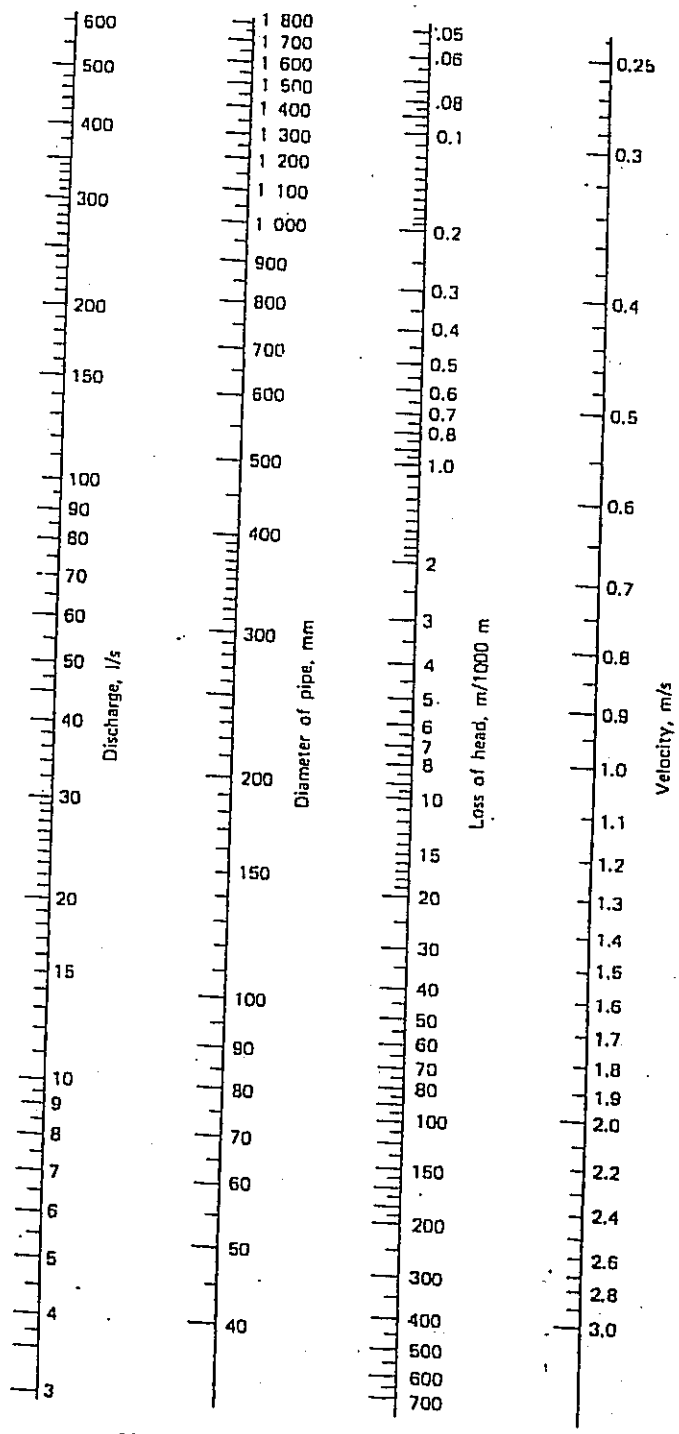
(ii) Equivalent population contributing the amount of solids [03 marks]

(iii) Volume of the digester [04 marks]

(c) In rural areas or in case of isolated buildings complete treatment of sewage is neither feasible nor economical.

(i) List various onsite disposal facilities that can be used for low population densities. [01 marks]

(ii) Drain fields are used to discharge effluents in such systems. A rural community produce a wastewater flow of $40m^3$/day. Assuming the depth of a trench, calculate the drain length of a drain field. Percolation rate of a soil is given as 20liters/m^2/day and dimensions of drain field are given by the equation $L = \frac{NQ}{2DI}$ with usual notations. [04 marks]



Nomograph for Hazen Williams Formula, based on $C = 100$.