NATIONAL EXAMS DECEMBER 2016

04-ENV-A2 HYDROLOGY AND MUNICIPAL HYDRAULICS ENGINEERING

3 hours duration

NOTES

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is a Closed Book Exam with a candidate prepared $8\frac{1}{2}''$ x $11''$ double sided Aid-Sheet allowed.

3. Candidates may use one of two calculators, the Casio or Sharp approved models. Write the name and model designation of the calculator on the first inside left hand sheet of the exam work book.

4. Any five (5) questions constitute a complete paper. Only the first five (5) answers as they appear in your work book(s), will be marked.

5. Each question is worth a total of 20 marks with the section marks indicated in brackets ( ) at the left hand margin of the question. The complete Marking Scheme is also provided on the final page. A completed exam consists of five (5) answered questions with a possible maximum score of 100 marks.

Problem 1

Provide answers to the following questions related to *precipitation and snow melt, wastewater collection system* and *infiltration, storm frequency and duration analysis.*

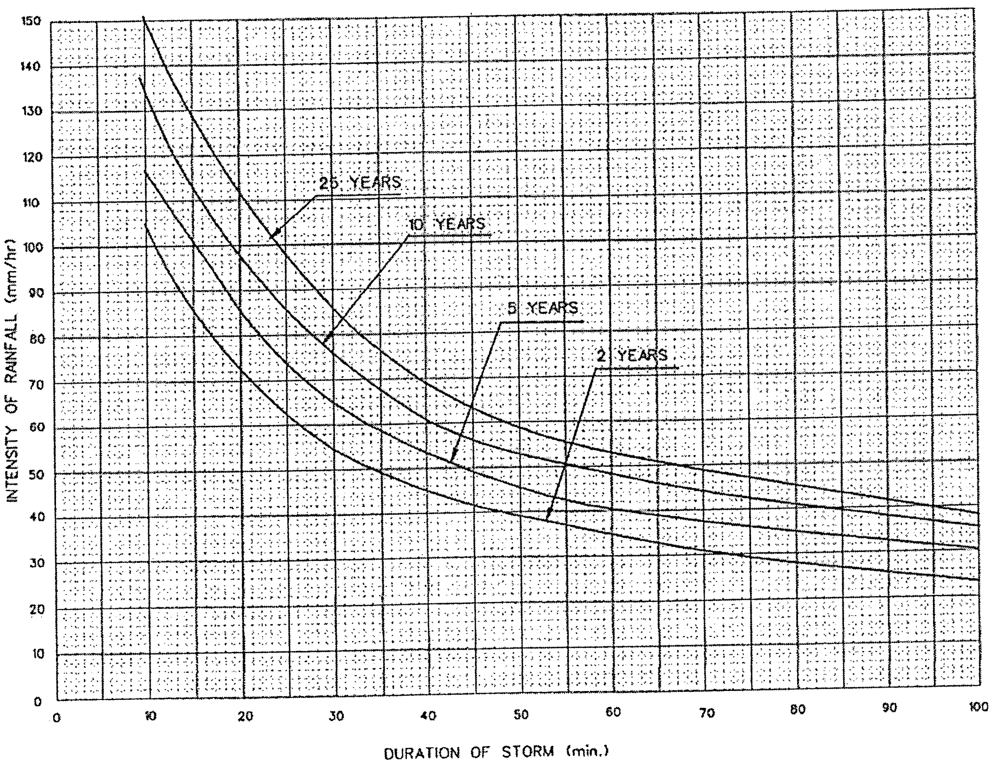
(6) (i) Briefly explain two (2) engineering methods or principles that may need to be used when considering snow melt in the design of hydraulic structures as opposed to rainfall precipitation.

(6) (ii) Briefly explain the function or importance of the following components of a wastewater collection system:

(a) Sewage pumping station; and

(b) Daily per capita sewage flow;

(8) (iii) Give an example of the use of the Intensity Duration Frequency (IDF) curves (below) in the design of a main trunk storm sewer to deal with runoff from a large parking lot during a 10-year return storm event.



Problem 2

Provide answers to the following questions related to *conceptual models of runoff*, *hydraulics of closed pipe systems* and *water distribution systems*.

(8) (i) Briefly describe three (3) features of an empirical runoff model and a reservoir based model. For each model, describe a situation where one model is preferred over the other in predicting the runoff from excess rainfall.

(ii) Consider water flowing though a PVC pipe having length L of 2000 m, diameter d of 400 mm and a full flow rate of 8000 L/s. Stating clearly and justifying any assumptions, calculate the following:

(2) (a) The average fluid velocity V in m/s.

(2) (b) Reynolds number Re and type of flow (i.e., laminar or turbulent).

(2) (c) Pipe friction loss H_f in m.

(6) (iii) Briefly explain three (3) important functions of a storage reservoir within a water distribution system.

Problem 3

Provide answers to the following questions related to *components* and *processes* of the *natural hydrologic cycle* and *stormwater collection system design*.

(7) (i) Provide a simple labelled schematic showing the natural hydrologic cycle of a watershed connected to a lake and briefly explain how the hydrological cycle works.

(7) (ii) Briefly explain what in-line storage is, two (2) of its important design considerations and its primary function in a stormwater collection system.

(6) (iii) Storm sewer pipe sizing is commonly based on Manning's Equation (below). Briefly explain three (3) important underlying assumptions that an engineer needs to consider when using this equation.

$$Q = \frac{1}{n} \cdot A \cdot R^{\frac{2}{3}} \cdot S^{\frac{1}{2}}$$

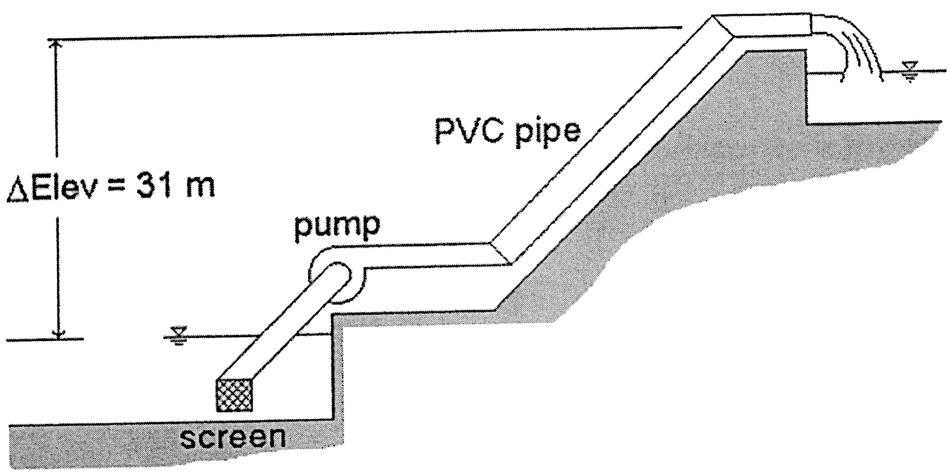
Problem 4

Provide answers to the following questions related to *stream flow and hydrograph analysis* and *basic pumps or prime movers.*

(6) (i) Briefly explain the concepts of recession curve, base flow and direct runoff as they relate to a runoff hydrograph and stream flow. Provide a simple labelled schematic of a typical runoff hydrograph.

(6) (ii) Briefly explain two (2) main factors that affect the hydrograph shape and explain how these factors impact the hydrograph analysis.

(8) (iii) Based on the pump configuration shown (below) calculate the total dynamic head (TDH) and the required brake horse power (BHP). Given a PVC pipe length L = 1500 m, friction factor $f = 0.014$, pipe diameter D = 295 mm, flow rate Q = 102 L/s and pump efficiency $E_{pump} = 0.7$. Assume that other losses in the system are negligible.

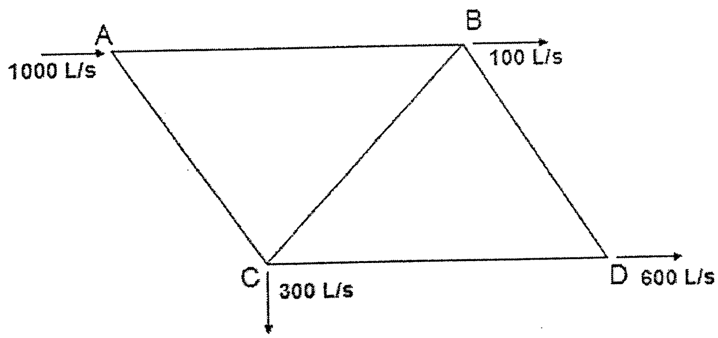


Problem 5

Provide answers to the following questions related to *pipe networks*, *network design* and *sanitary sewers design*.

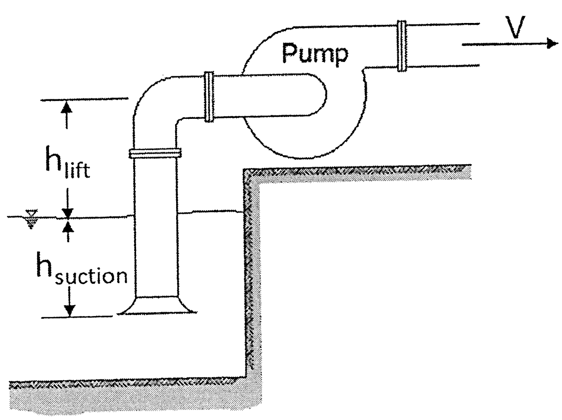
(10) (i) Solve for the flows in each pipe of the pipe network below (not to scale) using the Hardy-Cross or similar method, given the following pipe lengths and corresponding diameters:

Pipe	Length (m)	Diameter (mm)
AB	600	300
BC	700	350
CD	600	300
AC	500	250
BD	500	200



(5) (ii) Briefly explain the cavitation phenomenon in a water distribution system and give two (2) potential problems and two (2) solutions.

(5) (iii) Explain the significance of net positive suction head (NPSH) in a pump system similar to that shown below. As part of your explanation, give a definition of NPSH and explain two (2) key terms in the definition.



Problem 6

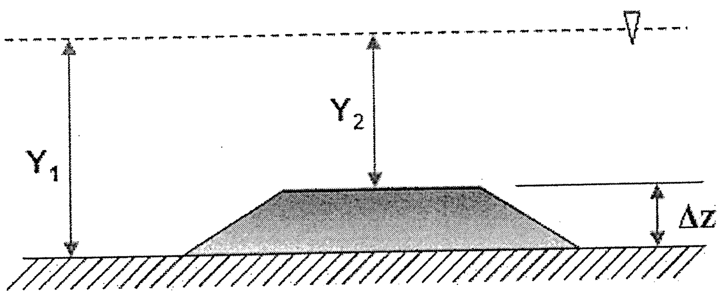
Provide answers to the following questions related to *open channel flows* under *uniform* and *gradually varied flow* conditions and *sediment transport.*

(i) A sand lined trapezoidal channel experiences uniform flow at a normal depth of 4 *m*. The base width is 12 *m* and the side slopes are equal at a H:V of 1:4. Using an appropriate Manning's *n* and a bed slope S_o of 3 % calculate the following:

(3) (a) The discharge flow rate Q in m^3/s; and

(3) (b) Reynolds number *Re* and type of flow (i.e., laminar or turbulent).

(8) (ii) Assume that the channel has a flow rate of 20 m^3/s at a normal flow depth Y_1 of 3 *m*. Calculate the depth of flow Y_2 in a section of the channel, 10 *m* downstream, in which the bed rises ΔZ equal to 1.0 *m*. Consider the figure below, assume frictional losses are negligible and you may use the *specific energy* equations at the two sections.



(6) (iii) Consider Stokes Law (below) and explain the limitation of Stokes Law in predicting the fall velocity (ω) for large grains ($D > 0.01$ m) when compared to practical limits.

$$\omega = \frac{D^2(\rho_s - \rho_w)g}{18\mu}$$

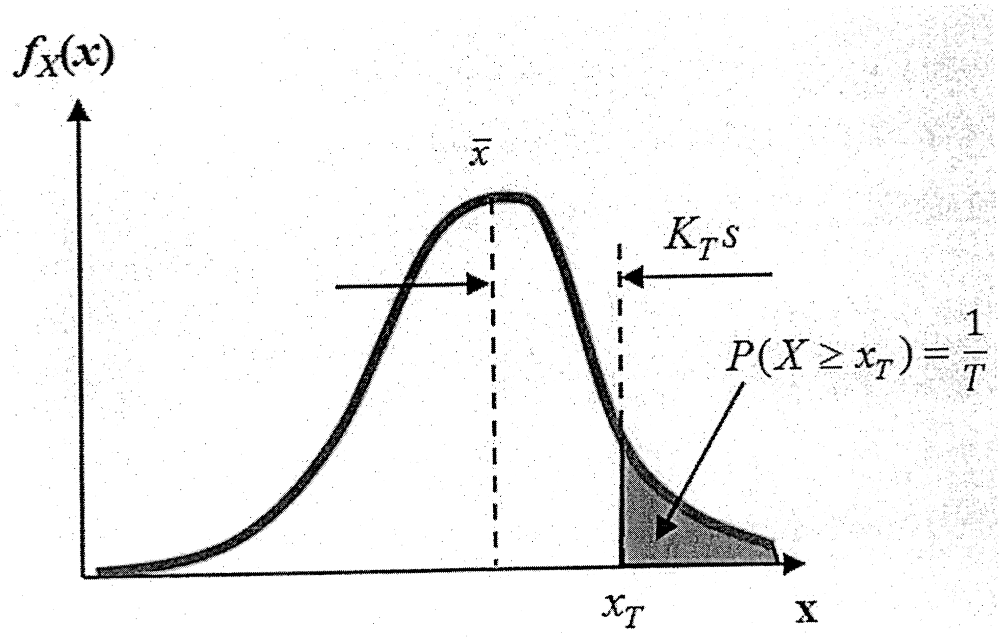
Problem 7

Provide answers to the following questions related to *urban drainage with runoff control system design, frequency and probability analysis related to precipitation, floods and droughts.*

(7) (i) Stormwater best management practices (BMPs) suggest that it is a good principle to detain runoff for the first 24-hours after a storm. Provide three (3) reasons why the use of stormwater management dry pond meets this BMP principle.

(8) (ii) Select an on-site and an off-site runoff control system and briefly explain two (2) key operational strategies necessary to ensure good system performance for a typical 20-year life of the systems.

(5) (iii) Floods and droughts are considered extreme events and typically, their magnitude is inversely related to their frequency of occurrence. The purpose of frequency and probability analysis is to determine the magnitude of events correlated to the frequency of occurrence. Considering the figure below, briefly explain how the event magnitude (x_T) is determined. Assume that K_T is the frequency factor, T is the return period, $\bar{x}$ is the mean magnitude of the event and s is the standard deviation.



Marking Scheme

1. (i) 6, (ii) 6, (iii) 8 marks, 20 marks total
2. (i) 8, (ii) (a) 2, (b) 2, (c) 2, (iii) 6 marks, 20 marks total
3. (i) 7, (ii) 7, (iii) 6 marks, 20 marks total
4. (i) 6, ii) 6, (iii) 8 marks, 20 marks total
5. (i) 10, (ii) 5, (iii) 5 marks, 20 marks total
6. (i) (a) 3, (b) 3, (ii) 8, (iii) 6 marks, 20 marks total
7. (i) 7, (ii) 8, (iii) 5 marks, 20 marks total