NATIONAL EXAMS DECEMBER 2019

18-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 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.

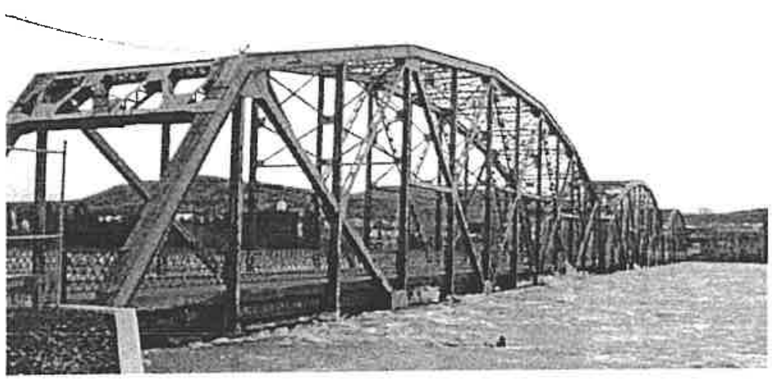
Problem 1

Provide answers to the following questions related to *sanitary sewers design*, *runoff control system design* and *probability frequency hydrograph analysis* related to *floods*.

(7) (i) You have been asked by the senior engineer to design a sanitary sewer to convey a peak flow of 300 m^3/s when flowing 100% full with a bedding slope of 4%. The senior engineer advises that the flow velocity must be greater than 0.6 m/s and less than 7 m/s and that a steel pipe with a Manning's n of 0.013 is to be used. Calculate the required sewer diameter in m under the stipulated conditions and check that all the conditions are met.

(6) (ii) Briefly describe two (2) different off-site stormwater runoff control systems. Briefly compare the design and operation issues for each system assuming that the systems are to be operated for a 25-year design life.

(7) (iii) To conduct risk analyses and dam safety evaluations, probability estimates for extreme floods are required. An extreme flood is considered to have an Annual Exceedance Probability (AEP) of 0.005 or less. Describe one method used to estimate extreme flood runoff hydrographs. Methods you may consider include the unit hydrograph approach, continuous rainfall-runoff modelling and methods that use statistical techniques.



Problem 2

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

(10) (i) Provide a schematic showing the natural hydrologic cycle identifying four (4) key components and briefly explain how two (2) components control surface runoff.

(10) (ii) Briefly explain four (4) key processes of the natural hydrologic cycle and how these processes are inter connected. *Note that components and processes are different.*

Problem 3

Provide answers to the following questions related to *stormwater collection system design* and *wastewater collection system design* and *precipitation and snow melt.*

(8) (i) Identify three (3) main components of a stormwater collection system and the main function of each component towards preventing flooding and erosion.

(6) (ii) Briefly explain two (2) important functions of a sanitary pumping station and two (2) operational and maintenance issues to prevent basements from flooding or overflowing into the natural environment.

(6) (iii) Large floods are often attributed to the melting of snow during a rain event. Explain three (3) watershed conditions that would also affect the flooding potential during precipitation with snow melt occurring at the same time.

Problem 4

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

(7) (i) Consider water flowing though a PVC pipe ($n = 0.017$) having length L of 3000 m, diameter d of 300 mm and a full flow velocity of 3 m/s. Calculate the following:

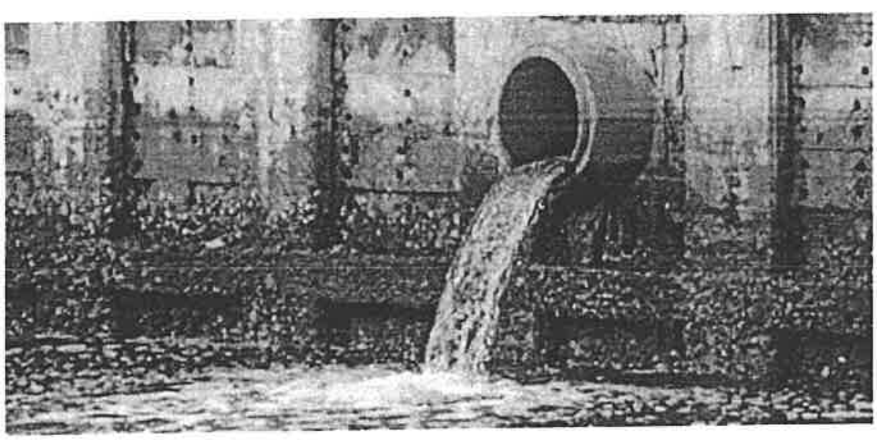
(a) The average flow rate Q in m^3/min.

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

(c) Pipe head loss H_f in m.

(6) (ii) Briefly describe three (3) main components of a water distribution system. Briefly explain how each component may affect the quality or quantity of water being distributed.

(7) (iii) Available observations are often not sufficient as a basis for decision making in water management. Conceptual runoff models are frequently used as tools to extend runoff series, compute design floods and predict effects of a climatic change. Give one (1) example of a conceptual model that can be used to predict the peak runoff. Briefly explain how the model can be calibrated and verified prior to being used for engineering design.



Problem 5

Provide answers to the following questions related to *streamflow* and *open channel flow* under *uniform* or *gradually varied flow* conditions.

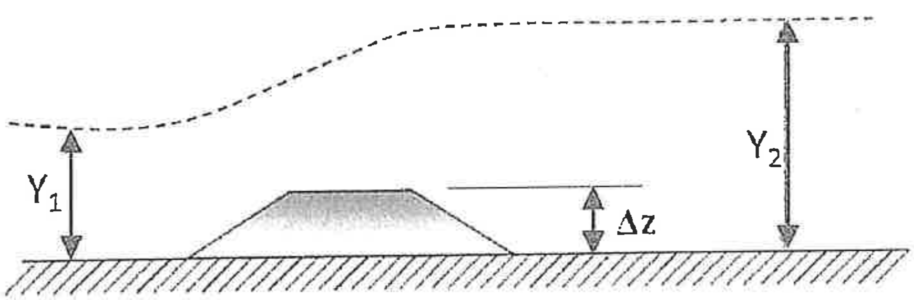
(7) (i) Streamflows have increased in some areas of Canada over the recent years. In an effort to predict streamflow changes, attempts have been made to model streamflows using the following five predictors: precipitation, antecedent wetness, temperature, agriculture and population density. Consider any three (3) of the given predictors and explain how each may influence the streamflow as a test of reasonableness of the model predictions.

(6) (ii) A grass lined trapezoidal channel experiences uniform flow at a normal depth of 2.0 m. The base width is 7 m and the side slopes are equal at a H:V of 1:3. Using an appropriate Manning's n and a bed slope S_o of 4 %, calculate the following:

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

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

(7) (iii) Assume that the above mentioned channel has a flowrate of 60 m^3/s at a normal flow depth Y_1 of 2.0 m. Calculate the depth of flow Y_2 in a section of the channel, 30 m downstream, in which the bed rises Δz equal to 0.7 m. Consider the figure below and assume frictional losses are negligible.



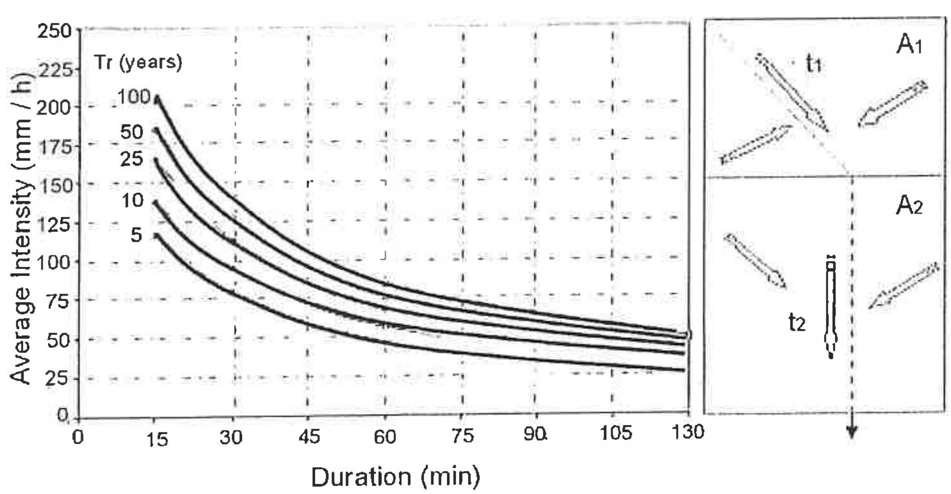
Problem 6

Provide answers to the following questions related to *urban stormwater management* and *intensity-duration frequency (IDF) analysis curves.*

(10) (i) Explain the basic design approach for a *stormwater wet pond* for quality control of surface runoff from an urban watershed. Assume that the primary objectives are downstream reduction in total suspended solids and nutrients. Briefly address two (2) maintenance issues important to ensure that the wet pond performs as designed.

(10) (ii) Use the Rational Formula to determine the 100-year design peak runoff (m^3/s) for the catchment areas (A1 and A2) shown below. Assume that the intensity duration frequency (IDF) curves given below are applicable for this area. Use the following design information:

Area Label	Area (ha)	Runoff Coefficient (C)	Time of Concentration t (min)
A1	30	0.6	40
A2	50	0.7	60



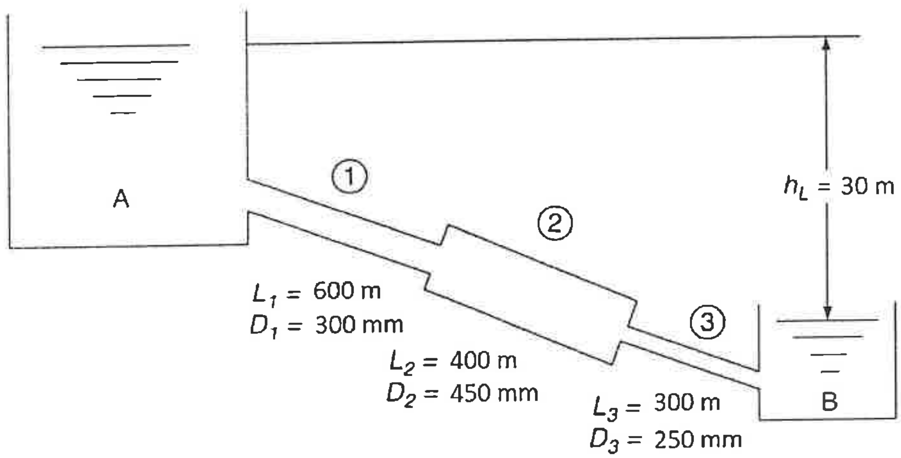
Problem 7

Provide answers to the following questions related to *pipe networks* and *basic pumps or prime movers*.

(6) (i) Calculate the equivalent pipe diameter (D_e) and the corresponding flow (Q) for the arrangement of three pipes in series between tank A and B in the figure below. Use the information provided in the figure, assume Darcy-Weisbach's friction factor $f = 0.05$ and ignore entry and exit (minor) losses. Recall the following equations:

$$D_e = \left(\frac{\sum_{i=1}^{N} L_i}{\sum_{i=1}^{N} \frac{L_i}{D_i^5}} \right)^{0.2} \qquad K_e = \left[\frac{8 f L_e}{\pi^2 g D_e^5} \right] \qquad Q = \left[\frac{h_L}{K_e} \right]^{0.2}$$

where $L_e = \sum L_i$ and K_e is a pipe constant.



(7) (ii) Briefly explain three (3) main assumptions or limitations when using the Hardy-Cross Method in designing a water network system. In you explanation, use equations and figures, as necessary to show how the assumptions are implemented.

(7) (iii) Provide a figure showing four (4) key points of an example system-pump curve for two (2) pumps in series. The figure should be clearly labelled and should clearly identify the single pump and dual pump characteristic curves, the system curve, the operating point and the shutoff head.

Marking Scheme

18-Env-A2 Hydrology and Municipal Hydraulics Engineering

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