

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BENG (HONS) CIVIL ENGINEERING

SEMESTER TWO EXAMINATION 2023/2024

HYDROLOGY AND ENVIRONMENTAL ENGINEERING

MODULE NO: CIE5017

Date: Tuesday 14th May 2024

Time: 2:00 – 4:00

INSTRUCTIONS TO CANDIDATES:

This is an open book examination

This exam paper contains two sections:
SECTION 'A' and SECTION 'B'

SECTION A contains TWO questions: you should answer BOTH questions. Each of these questions is worth 25 marks.

Section B contains TWO questions: you should answer BOTH questions. Each of these questions is worth 25 marks.

ANSWER EACH SECTION IN A SEPARATE ANSWER BOOKLET

Marks for parts of questions are shown in brackets.

This assessment carries 100 marks.

All working steps must be shown.

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SECTION A – HYDROLOGY (ANSWER BOTH QUESTIONS IN THIS SECTION)

Question 1

Two storms occur successively each of 2-hr duration with a rainfall excess of 2.0 cm and 2.5 cm, respectively. The 2-hr unit hydrograph (2-hr UH) is given in Table Q1.1 below:

Table Q1.1: Ordinates of the 2-hr Unit Hydrograph

Time (hr)	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
2-hr UH	0	6	14	22	36	65	94	80	64	50	36	25	18	16	10	8	5	2	0

- (a) Calculate the resulting Direct Runoff Hydrograph (DRH). **(9 marks)**
- (b) For the above, plot the unit hydrograph and the Derived Direct Runoff hydrograph (DRH) on the same chart. **(7 marks)**
- (c) Using the Ordinates of 4-Hr UH given in Table Q1.2 below, Derive the 12-Hr UH using the method of Superposition.

Table Q1.2: Ordinates of a 4-Hr Unit Hydrograph

Time (h)	0	4	8	12	16	20	24	28	32	36	40	44
Ordinate of 4-Hr UH	0	20	70	130	160	140	90	56	30	15	4	0

(9 marks)

Total 25 marks

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Question 2

Derive a Unit Hydrograph for a basin of 327 km² of area using the gross rainfall (Gross hyetograph) and the observed hydrograph as tabulated below in table Q2. Assume constant base flow of 100 m³ /s.

- (a) Calculate the losses **(18 marks)**
- (b) Draw the observed hydrograph and the derived unit hydrograph. **(7 marks)**

Table Q2: Total hydrograph and the Gross Hyetograph

Time (h)	Observed Hydrograph (m ³ /s)
0	100
1	100
2	400
3	700
4	1100
5	800
6	500
7	400
8	300
9	200
10	100
11	100

Time (h)	Gross precipitation (GRH) (cm/h)
0 – 1	1.2
1 – 2	2.5
2 – 3	2.3
3 – 4	0.5

Total 25 marks

END OF SECTION A

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SECTION B – ENVIRONMENTAL ENGINEERING (ANSWER BOTH QUESTIONS IN THIS SECTION)

Question 3

For the loop shown in Figure Q3 below, the inflows, outflows and dimensions have been indicated. Find the discharges in the loop (make no more than three trials). The pipes are all 25 cm cast iron ($e = 0.26$), $f = 0.02$ for $Re > 200,000$.

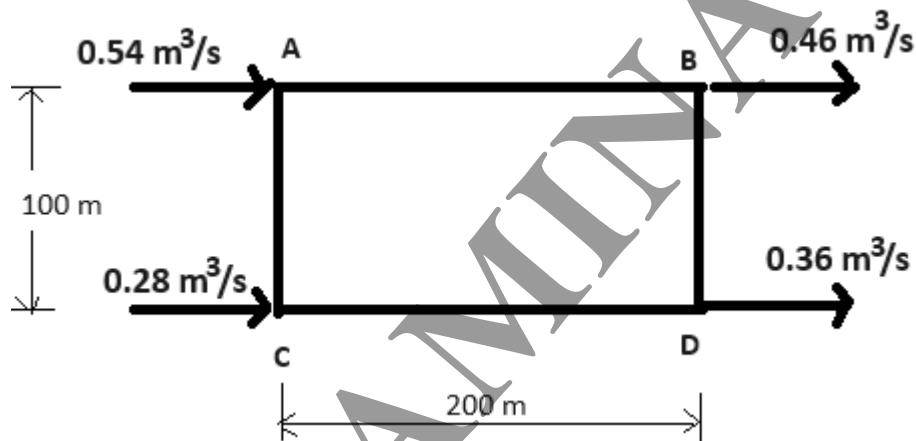


Figure Q3

(25 marks)

Total 25 marks

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Question 4

(a) Describe, difference between the BOD and COD of a water sample. **(3 marks)**

(b) A stream with $BOD_5 = 2 \text{ mg/L}$ and saturated with DO has a normal flow of $2.26 \text{ m}^3/\text{s}$ receives a sewage effluent discharge of $0.755 \text{ m}^3/\text{s}$, also saturated with DO, with a BOD_5 of 30 mg/L .

(i) Determine the DO deficits in the stream over the next 5 days.

(ii) Calculate the critical DO in the stream.

(iii) Calculate the time at which the critical DO occurs.

(iv) Hence plot the sag curve for this stream.

(v) Estimate the distance down the stream at which the critical DO occurs if the stream velocity is 0.3 m/s .

(vi) Comment on what happens after your calculated critical time.

Assume the same temperature of 20°C throughout the stream.

Take: $DO_{\text{sat}} = 9.17 \text{ mg/L}$

The reaction rate coefficient, $k_1 = 0.17 \text{ d}^{-1}$

The reaeration coefficient, $k_2 = 0.4 \text{ d}^{-1}$

(22 marks)

Total 25 marks

END OF SECTION B

END OF PAPER