The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Civil Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: CVX 4241 Engineering Hydrology**
Academic Year	: 2019/2020
Date	: 10th August 2020
Time	: 1330-1630hrs
Duration	**: 03 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **SIX (06)** questions on **Five (06)** pages.
3. Answer **Any FIVE (05)** questions.
4. Answer for each question should commence from a new page.
5. Necessary additional information is provided.
6. This is a Closed Book Test (CBT).
7. Answers should be in clear hand writing.
8. Do not use Red colour pen.

Question 1

1.1 State three methods of estimating surface water evaporation. (3 Marks)

1.2 A reservoir with a surface area of 250 hectares has the following average values of climate parameters during a week: Water temperature = 20°C, Relative humidity = 40%, Wind velocity at 1.0 m above ground surface = 16 km/h. Estimate the average daily evaporation from the lake by using Meyer's formula.
(7 Marks)

1.3 An ISI Standard evaporation pan at the site is found to have a pan coefficient of 0.80 based on calibration against controlled water-budgeting method. If this pan indicates an evaporation of 72 mm in the week under question,

(i) estimate the accuracy of Meyer's method relative to the pan evaporation measurements. (5 Marks)

(ii) estimate the volume of water evaporated from the lake in that week. (5 Marks)

Meyer's formula

$$E_L = K_M\,(e_w - e_a)\,\left(1 + \frac{u_9}{16}\right)$$

$$u_h = Ch^{1/7}$$

Question 2

2.1 Estimate the potential evapotranspiration from an area near Colombo in the month of November by Penman's formula. The following data are available: (12 Marks)

Latitude	: 28°4' N
Elevation	: 230 m (above sea level)
Mean monthly temperature	: 19° C
Mean relative humidity	: 75%
Mean observed sunshine hours	: 9 h
Wind velocity at 2 m height	: 85 km/day
Nature of surface cover	: Close-ground green crop
Psychrometric constant	: 0.49 mm Hg/°C
b	: 0.52

2.2 Estimate the daily evaporation from a lake situated in the same area. (8 marks)

Penman's formula

$$PET = \frac{AH_n + E_a\gamma}{A + \gamma}$$

$$H_n = H_a(1-r)\left(a + b\frac{n}{N}\right) - \sigma T_a^4(0.56 - 0.092\sqrt{e_a})\left(0.10 + 0.90\frac{n}{N}\right)$$

$$E_a = 0.35\left(1 + \frac{u_2}{160}\right)(e_w - e_a)$$

$$a = 0.29\cos\emptyset$$

Question 3

3.1 Indicate the following listed components on a hydrograph and describe each component

(6 Marks)

i. The rising limb
ii. The crest segment
iii. The recession limb

3.2 A storm over a catchment of area 5.0 km^2 had a duration of 14 hours. The mass curve of rainfall of the storm is as follows:

Time from start of storm (h)	0	2	4	6	8	10	12	14
Cumulative rainfall (cm)	0	0.6	2.8	5.2	6.6	7.5	9.2	9.6

If the ϕ index for the catchment is 0.4 cm/h, obtain the effective rainfall hyetograph and determine the volume of direct runoff from the catchment due to the storm.

(14 Marks)

Question 4

4.1 State the difference between S-curve method and method of superposition.

(5 Marks)

4.2 Derive the S-curve for the 4-h unit hydrograph given below. (15 Marks)

Time (h)	0	4	8	12	16	20	24	28
Ordinate of 4-h unit hydrograph ($m^3/s/cm$)	0	10	30	25	18	10	5	0

Muskingum equation

$S = K[xI + (1 - x)Q]$

Question 5

5.1 Define the time of concentration (t_c) of a catchment. (3 Marks)

5.2 A drainage basin has the following characteristics: Area = 110 km^2, time of concentration = 18 h, storage constant = 12 h and inter-isochrone area distribution as below;

Travel time t(h)	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18
Inter-isochrone area (km^2)	3	9	20	22	16	18	10	8	4

Determine the instantaneous unit hydrograph (IUH) for this catchment.
(17 Marks)

Modified Muskingum routing equation

$Q_2 = 2C_1I_1 + C_2Q_1$

Question 6

6.1 Figure 1 below describes a steady confined flow towards the well. Stating all the assumptions, derive the following equation. (8 Marks)

$$h - h_o = (h_o - h_w)\frac{ln(r/r_w)}{ln(r_o/r_w)}$$

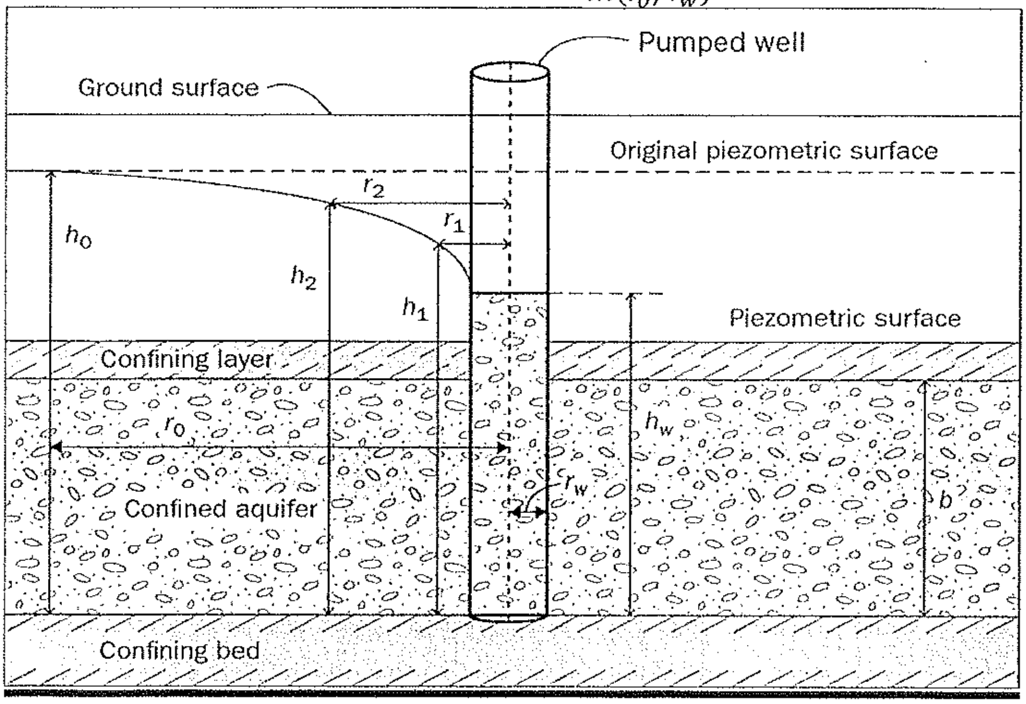

Figure 1: Radial flow to a well in a confined aquifer

6.2 An unconfined aquifer is recharged monthly as follows: The recharge is 5 cm for December, 7 cm for January, 4 cm for February, 5 cm for March, 3 cm for April, and

2 cm for May. Taking the value of k as 1 month, compute the groundwater runoff. (12 marks)

Data tables

Table 1 ***Saturation Vapour Pressure of Water***

Temperature (°C)	Saturation vapour pressure e_w (mm of	A(mm/°C)
0	4.58	0.30
5.0	6.54	0.45
7.5	7.78	0.54
10.0	9.21	0.60
12.5	10.87	0.71
15.0	12.79	0.80
17.5	15.00	0.95
20.0	17.54	1.05
22.5	20.44	1.24

Table 2 Mean Monthly Solar Radiation at the Top of Atmosphere, Ha in mm of Evaporable Water per Day

North latitude	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0^0	14.5	15.0	15.2	14.7	13.9	13.4	13.5	14.2	14.9	15.0	14.6	14.3
10^0	12.8	13.9	14.8	15.2	15.0	14.8	14.8	15.0	14.9	14.1	13.1	12.4
20^0	10.8	12.3	13.9	15.2	15.7	15.8	15.7	15.3	14.4	12.9	11.2	10.3
30^0	8.5	10.5	12.7	14.8	16.0	16.5	16.2	15.3	13.5	11.3	9.1	7.9
40^0	6.0	8.3	11.0	13.9	15.9	16.7	16.3	14.8	12.2	9.3	6.7	5.4
50^0	3.6	5.9	9.1	12.7	15.4	16.7	16.1	13.9	10.5	7.1	4.3	3.0

Table 3 Mean Monthly Values of Possible Sunshine Hours

North latitude	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0^0	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1
10^0	11.6	11.8	12.1	12.4	12.6	12.7	12.6	12.4	12.9	11.9	11.7	11.5
20^0	11.1	11.5	12.0	12.6	13.1	13.3	13.2	12.8	12.3	11.7	11.2	10.9
30^0	10.4	11.1	12.0	12.9	13.7	14.1	13.9	13.2	12.4	11.5	10.6	10.2
40^0	9.6	10.7	11.9	13.2	14.4	15.0	14.7	13.8	12.5	11.2	10.0	9.4