



# KARATINA UNIVERSITY

## UNIVERSITY EXAMINATIONS 2023/2024 ACADEMIC YEAR

### FOURTH YEAR SECOND SEMESTER REGULAR EXAMINATION

FOR THE DEGREE OF:

BACHELOR OF EDUCATION SCIENCE

COURSE CODE: MAT 424

COURSE TITLE: FLUID MECHANICS III

DATE: 16<sup>TH</sup> APRIL 2024

TIME: 3PM- 5PM

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#### INSTRUCTION TO CANDIDATES

- SEE INSIDE

**INSTRUCTIONS:** Answer ALL questions in section A and any other TWO questions in section B.

**SECTION A (30 marks)**

**QUESTION ONE (30 marks)**

- a) Briefly explain the hydrologic cycle (5 marks)
- b) The rainfall figures for successive 30-minute intervals are 35, 40, 120, 85, 45, 45 and 30mm/hr. If the  $\Phi$ -index is 35mm/hr, Determine  $\omega$ -index. (5 marks)
- c) A unit hydrograph of a drainage basin is triangular in form with a height of 50m<sup>3</sup>/s. and a base of 15 hours. Determine the area (in km<sup>3</sup>) of the drainage basin. (3 marks)
- d) At a particular time, the storage in a river reach is 60 × 10<sup>3</sup> m<sup>3</sup>. At that time, the inflow into the reach is 10 m<sup>3</sup>/s and the outflow is 16 m<sup>3</sup>/s. after two hours, the inflow and the outflow are 18 m<sup>3</sup>/s and 20 m<sup>3</sup>/s respectively. Determine;
- (i) the change in storage during two hours period. (4 marks)
- (ii) the storage volume after two hours. (2 marks)
- e) The precipitation on a catchment in Dubai of area 95Km<sup>2</sup> is sampled in the table below. Determine the precipitation recorded by the station 7, if the mean precipitation as computed by Thiessen method amounts to 98mm. (5 marks)

Station	Recorded rainfall (mm)(February)	Thiessen polygon area (Km <sup>2</sup> )
1	84	4.0
2	90	4.0
3	120	10.0
4	86	5.1
5	87	15.1
6	76	30.6
7	X	6.2
8	131	20.0

- (f) Name and discuss the zones where ground water is found. (6 marks)

## SECTION B (40 marks)

### QUESTION TWO (20 marks)

- a) Rain gauge X was out of operation for a month during which there was a storm. The rainfall amounts at 3 adjacent stations A, B and C were 37, 42 and 49 respectively. The average annual precipitation amounts for the gauges are  $X = 694, A = 726, B = 752$  and  $C = 760$ . Estimate the amount of rainfall for gauge X using Arithmetic method. **(4 marks)**
- b) Check whether continuity is satisfied by the following flow fields:
- (i)  $u = x^2y + y^3, v = x^3 - xy^2$  **(2 marks)**
- (ii)  $u = \sin^2(xy), v = \cos^2(xy)$  **(3 marks)**
- c) A 6-hour rainfall of 6cm at a place A was found to have a return period of 40 years. Find the probability that a 6-hour rainfall of this magnitude will occur at least once in 20 successive years. **(4 marks)**
- d) State the steps followed in watershed modelling. **(7 marks)**

### QUESTION THREE (20 marks)

- a) An inflow hydrograph is measured for a cross-section of a reach. Compute the outflow hydrograph at by means of the Muskingum method. Assume  $k=2, x=0.15$ , and the outflow equals the inflow initially. **(8 marks)**

Time(hrs)	0	2	4	6	8	10	12	14	16
Inflow(m <sup>3</sup> /s)	60	200	600	930	440	250	180	80	60

- b) A lake reservoir of 100ha of surface area has a saturation vapour at 30°C of 35mm of Hg. The actual vapour pressure at 9m above the ground is 50% of the saturation vapour pressure. If the wind velocity at 2m above the ground is 13km/hr, determine the average daily evaporation from the lake reservoir. **(6 marks)**
- c) (i) State Darcy's law. **(2 marks)**
- (ii) Losses from lake A feed Lake B. The distance between the two lakes is 3.5km. the water level in lake A is at 1100m and in lake B at 1060m. Given that  $K = 12.5\text{m/day}$  and  $n = 15\%$ , calculate the specific flow rate ( $q_x$ ) and the flow rate through the pores. **(4 marks)**

#### **QUESTION FOUR (20 marks)**

(a) The isohyets for annual rainfall over a catchment basin indicated below.

Isohyet	Area in square km.
45 – 55	500
55 – 65	1000
65 – 75	2000

Estimate the average annual precipitate depth in cm over the basin. **(5 marks)**

(b) An incompressible plane flow has the velocity components  $u = 2y$ ,  $v = 8x$ ,  $w = 0$ .

(i) Find the acceleration components. **(3 marks)**

(ii) Determine whether this flow satisfies the Navier-Stokes equations. (Neglect gravity and assume constant viscosity. **(2 marks)**

(c) Briefly discuss Inverse distance weighting and Thiessen polygon method as methods of measuring the average precipitation over an area and write their formulas. **(10 marks)**

#### **QUESTION FIVE (20 marks)**

a) A lake has a surface area of  $708,000\text{m}^2$ . In May, the river A flow into the lake at an average rate of  $1.5\text{m}^3/\text{s}$ . River B flows out of the lake at an average rate of  $1.25\text{m}^3/\text{s}$ . the evaporation rate was measured as  $14\text{cm}/\text{month}$ . A total of  $22.5\text{cm}$  of the precipitation fell in May. The average depth of the lake on May 1<sup>st</sup> was  $19\text{cm}$ . calculate the average depth on May 30<sup>th</sup>. (Seepage losses are negligible). **(8 marks)**

b) Total rainfall of a catchment area in 6 hours is shown in the table below. The  $\Phi$ -index of the area for a certain surface run-off is found to be  $9\text{mm}/\text{hr}$ .

Time (hours)	0	1	2	3	4	5	6
Rainfall intensity (mm/hr)	0	5	15	20	20	14	1

Determine

(i) The value of surface run-off producing a  $\Phi$ -index of  $9\text{mm}/\text{hr}$ . **(2 marks)**

(ii) Total rainfall in the catchment area. **(2 marks)**

c) State and discuss 4 hydrological losses in water resources **(8 marks)**