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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	GROUNDWATER ENGINEERING
COURSE CODE	:	BFW40403
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JULY/AUGUST 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1.ANSWER **ALL** QUESTIONS IN **PART A** AND **TWO (2)** QUESTIONS IN **PART B** 2.THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK**. 3.STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK.

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

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PART A

Q1 (a) Briefly explain **THREE (3)** factors on occurrences of groundwater existence.
(i) Porosity
(ii) Permeability
(iii) Specific storage

(3 marks)

(b) Differentiate with diagrams between **THREE (3)** types of the aquifer.

(6 marks)

(c) In a year, water balance for a lake included rainfall P = 1145 mm/year, evaporation E = 830 mm/year, surface inflow I = 45 mm/year, surface outflow O = 124 mm/year, and change in storage ΔS = 55 mm/year. Estimate the net groundwater flow for the lake. Comment groundwater flow from this answer.

(8 marks)

(d) Explain in your words how to determine the new water table on site in engineering method and conclude of groundwater fluctuation phenomena during monitoring time.

(8 marks)

Q2 (a) Groundwater remediation techniques are mainly divided into two technologies which are ex-situ and in-situ. Describe **TWO (2)** technologies that are involved within each of the techniques.

(5 marks)

(b) An aquifer has a hydraulic conductivity of 2×10^{-5} m/s, a hydraulic gradient of 0.003 m/m, an effective porosity $n_e = 0.2$, and an effective diffusion $D = 0.5 \times 10^{-9}$ m²/s. A chloride solution with a concentration of 500 mg/L penetrates the aquifer along a line source. Calculate by appropriate equations for the chloride concentration at a distance of 20 m from the point of entry, after a period of 2 years.

(9 marks)

(c) Relate the common techniques used for monitoring groundwater systems to groundwater protection and investigation.

(5 marks)

(d) In your opinion, explain the process of groundwater recharge on the vadose zone soil water budget into **THREE (3)** distinct processes.

(6 marks)

PART B

Q3 (a) Describe the groundwater present in relation to the aquifer type, using numbering to highlight the point, as shown in **Figure Q3(a)**, according to your understanding.

(3 marks)

(b) Using the concept of resistors connected in parallel and the formula to calculate the equivalent resistance, determine the value of the equivalent resistance for a combination of 5 resistors. The resistors have a uniform resistance of 100 ohms, and each has been cut into equal parts of a length and sectional area before being connected in parallel.

(6 marks)

(c) A river and a canal run parallel to each other L = 500 m apart as shown in **Figure Q3(c)** comes with a fully penetrating unconfined aquifer with a hydraulic conductivity of 0.3 m/day. The water surface elevation in the river is 1.25 m lower than in the canal where the depth is 5 m. Assuming no recharge, find

(i) water table elevation midway between the river and the canal.

(ii) discharge into the river. Justify the seepage value in $m^3/(m/day)$ and flow direction.

(8 marks)

(d) Create a diagram that synthesizes the interaction between surface water and groundwater systems, using the concept of gaining and losing streams to illustrate the validation of this connection in typical landscapes.

(8 marks)

Q4 (a) Discuss the significance of groundwater movement in civil engineering.

(3 marks)

(b) A field sample of an unconfined aquifer is packed in a test cylinder. The length and diameter of the cylinder are 1 m and 10 cm, respectively. The field sample is tested for a period of 15 minutes under a constant head difference of 16.7 cm. As a result, 65.8 cm^3 of water is collected at the outlet. Compute hydraulic conductivity of the aquifer sample.

(6 marks)

(c) A stratum of clean sand and gravel between two channels has a hydraulic conductivity K = 0.1 cm/s and is supplied by water from a ditch (h_0 = 6.5 m deep) that penetrates to the bottom of the stratum. If the water surface in the second channel is 4 m above the bottom of the stratum and its distance to the ditch is x = 150 m (which is also the thickness of the stratum), illustrate and distinguish the unit flow rate in the gallery.

(8 marks)

(d) Develop a comprehensive theory of mechanisms or processes that explains the movement of contaminants in the subsurface via groundwater flow. Additionally, provide an example that highlights this scenario, examining the long-term effects of groundwater contamination on local ecosystems, the economy, and public health.

(8 marks)

Q5 (a) Exemplify the purposes of the water well from the perspective of the civil engineer.

(3 marks)

(b) A well is being pumped at a constant rate of 0.004 m^3/s. Given that $T = 0.0025$ m^2/s, $r = 100$ meters and storage coefficient = 0.00087. For W(u) at 15 minutes = 0.23 and 10 hours = 4.25. Find the drawdown in the observation well for a time period of

(i) 15 minutes

(ii) 10 hours

From your estimation, what does the mean difference values between the two periods?

(6 marks)

(c) A step test was carried out in four 2 hours steps. **Table Q5(c)** shows data obtained for yield (Q) and corresponding drawdown (s_w) in the pumping well. Determine

(i) value of losses

(ii) percent of well efficiency drops. Comment on your pattern of a forecasting method.

(8 marks)

(d) A fully penetrating well in a confined aquifer with 30 m thickness is pumped at a rate of 0.099 m^3/sec for 400 min. The drawdown measured at an observation well located 200 m away is given in **Table Q5(d)(i).** By using the Cooper-Jacob method, calculate

(i) transmissivity,

(ii) hydraulic conductivity. Categorize the type of layer as shown in **Table 5(d)(ii).**

(8 marks)

–END OF QUESTIONS–

FINAL EXAMINATION

SEMESTER/SESSION	: SEM II / 2022/2023	PROGRAMME CODE	: BFF
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FIGURES

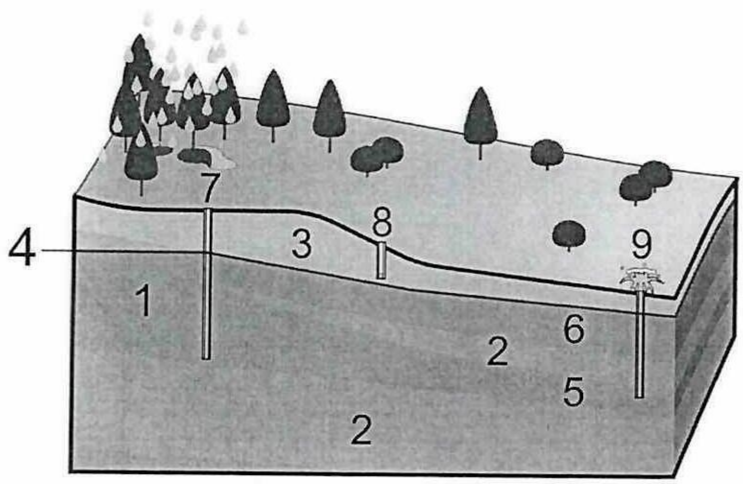

FIGURE Q3(a): Groundwater profile in subsurface layer

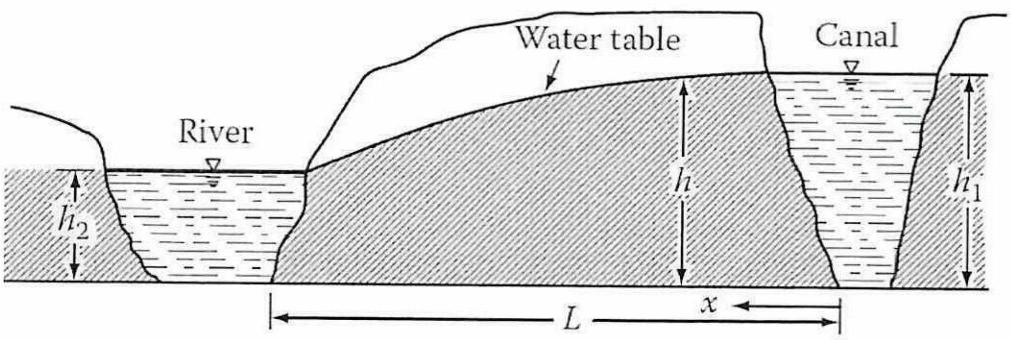

FIGURE Q3(c): Open channel cross section

FINAL EXAMINATION

SEMESTER/SESSION : SEM II / 2022/2023
COURSE NAME : GROUNDWATER ENGINEERING
PROGRAMME CODE : BFF
COURSE CODE : BFW40403

TABLES

Table Q5(c): Pumping test

Step	Q (l/s)	s_w (m)
Rest	0	0
1	14.7	1.43
2	31.5	3.46
3	44.4	5.41
4	57.6	8.90

Table Q5(d)(i): Drawdown data

Elapsed Time (min)	Drawdown (m)	Elapsed Time (min)	Drawdown (m)
1	0.158	30	0.505
2	0.205	40	0.536
3	0.268	50	0.536
4	0.282	60	0.568
5	0.315	70	0.568
6	0.347	80	0.583
7	0.347	90	0.583
8	0.363	100	0.599
9	0.378	200	0.646
10	0.394	300	0.678
20	0.473	400	0.710

Table Q5(d)(ii): Typical values of hydraulics conductivity and materials of layer

Materials	Range of K (m/day)
Clay soils (surface)	0.2
Deep clay beds	10^{-8} - 10^{-2}
Loam soils (surface)	0.1 - 1
Fine sand	1 - 5
Medium sand	5 - 20
Coarse sand	20 - 100
gravel	100 - 1000
Sand and gravel mixes	5 - 100
Clay, sand and gravel mixes (till)	0.001 – 0.1

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EQUATIONS

$$d^2(h^2)/dx^2 = 0$$

$$h^2 = c_1 x + c_2$$

$$q = -Kh\left(\frac{dh}{dx}\right) = K(h_1^2 - h_2^2)/2L$$

$$K = \frac{\forall L}{Ath} \qquad K = \frac{r^2 L}{R^2 t}\ln\frac{h_1}{h_2}$$

$$u = \frac{r^2 S}{4tT} \qquad q = \frac{K}{2x}(h_0^2 - h^2) \qquad s = \frac{QW(u)}{4\pi t}$$

$$T = \frac{2.3Q}{4\pi\Delta s'} \qquad T = K \qquad S = \frac{2.25Tt_0}{r^2}$$

$$v = \frac{K}{n_e} dh/dx \qquad A = \pi r^2 \qquad Q_s = -K_s\frac{dh}{dx}A$$

$$\alpha_L \approx 0.0175L^{1.46} \qquad p_e = vL/D_L \qquad D_L = \alpha_L v + D^*$$

$$C(x,t) = \frac{C_0}{2}\left[erfc\left(\frac{x - vt}{2\sqrt{D_L t}}\right) + \exp\left(\frac{vx}{D_L}\right) erfc\left(\frac{x + vt}{2\sqrt{D_L t}}\right)\right]$$

$$R_{eq} = R_1 + R_2 + R_3 + \ldots\ldots$$

$$1/R_{eq} = 1/R_1 + 1/R_2 + 1/R_3 + \ldots\ldots$$