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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER II
SESSION 2020/2021

COURSE NAME	:	GROUND WATER ENGINEERING
COURSE CODE	:	BFW 40403
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JULY 2021
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS IN **PART A** AND **THREE (3)** QUESTIONS IN **PART B**

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

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PART A

Q1 (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 x 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 x 10^{-9} m^2/s. A chloride solution with a concentration of 500 mg/L penetrates in the aquifer along a line source. Calculate by using appropriate equations for the chloride concentration at a distance of 20 m from the point of entry, after a period of 2 years.

(8 marks)

(c) Relate the monitoring work and site remediation to groundwater protection and investigation in terms of groundwater flow and the transport of contaminants

(5 marks)

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

(7 marks)

PART B

Q2 (a) Briefly explain **THREE (3)** factors on occurrences of groundwater existence.

(3 marks)

(b) Differentiate with diagrams between **THREE (3)** types of 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) If water table drops 40 m, the change in inter-granular pressure at the bottom of the sand layer occurs. Consider a 60 m thick sand layer and the water table is located at a depth of 10 m below the groundwater surface. Determine new water table and conclude with an example of groundwater phenomena.

(8 marks)

Q3 (a) Describe **TWO (2)** techniques consists of resistivity application and its purposes.

(3 marks)

(b) Explain the resistivity works process. From your observation, explain the possible image depth reflected or appears to be at the 400 m distance reach?

(6 marks)

(c) A river and a canal run parallel to each other L = 500 m apart as shown in **Figure Q3(c)** it comes with a fully penetrate unconfined aquifer with a hydraulic conductivity of 0.3 m/day. The elevation of the water surface 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) Surface water and groundwater systems are connected in most landscapes. Validate this interaction by illustrating in terms of inferring the gaining and losing stream.

(8 marks)

Q4 (a) Discuss groundwater flow characteristics in terms of groundwater movement.

(3 marks)

(b) A field sample of an unconfined aquifer is packed in a test cylinder. 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 into the gallery.

(8 marks)

(d) Formulate **TWO (2)** relationships of the laboratory experiment as shown in **Figure Q4(d)** to Darcy's Law. Adapt this fundamental concept on-site investigation work for hydraulic conductivity determination.

(8 marks)

Q5 (a) Exemplify the purposes of water well in a perspective of 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 differ values between two periods.

(6 marks)

(c) A step test was carried out 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 forecasting method.

(8 marks)

(d) A fully penetrating well in a confined aquifer with 30 m thickness is pumped at rate of 0.099 m^3/sec for 400 min. 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–

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FIGURES

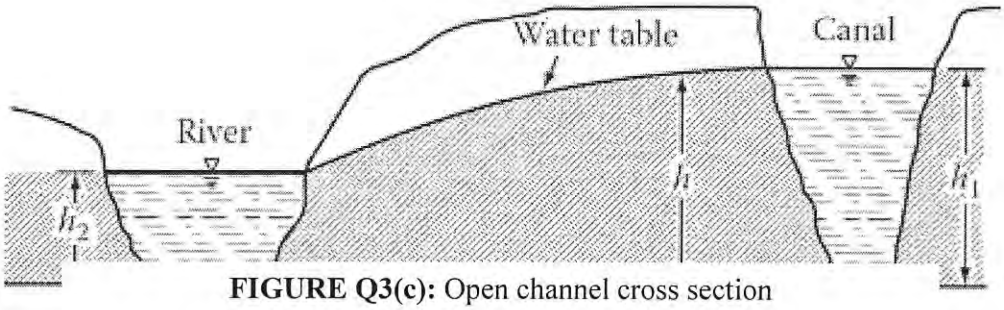

FIGURE Q3(c): Open channel cross section

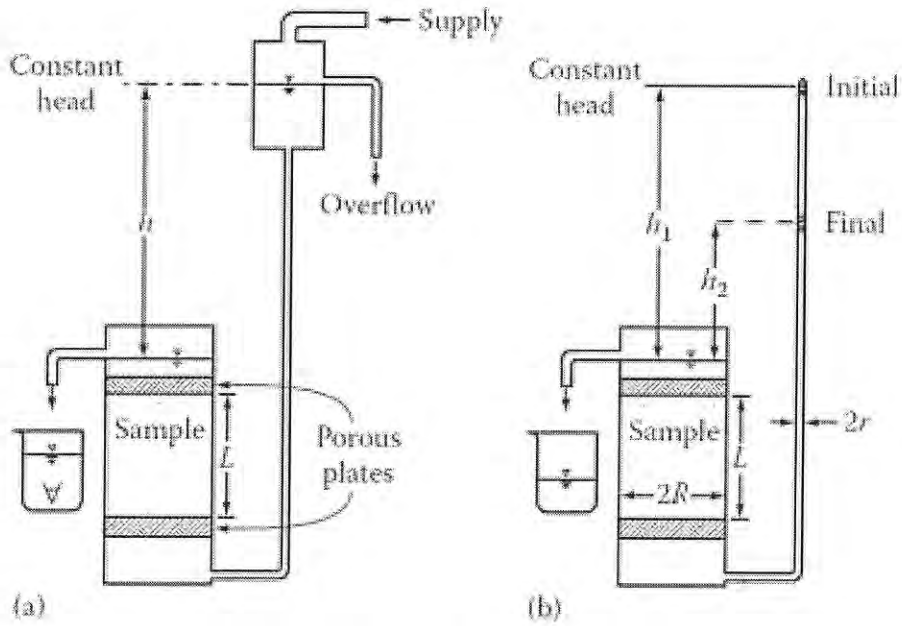

FIGURE Q4(d): Experimental samples

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TABLES

Step	Q (l/s)	s_W (m)	Q/s_W (m^2/day)
Rest	0	0	0
1	14.7	1.43	888
2	31.5	3.46	787
3	44.4	5.41	709
4	57.6	8.90	559

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

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

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

$$h^2 = c_1x + c_2$$

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

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

$$u = \frac{r^2S}{4tT} \qquad s = \frac{QW(u)}{4\pi t}$$

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

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

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

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