Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	GROUNDWATER ENGINEERING
COURSE CODE	:	BFW40403
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JUNE / JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS IN PART A AND **FOUR (4)** QUESTIONS IN PART B.

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

PART A

Q1 (a) Identify **TWO (2)** purposes of test pumping water well.

(2 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 the storage coefficient = 0.00087. Given *W(u)* at 15 minutes = 0.23 and 20 hours = 8.49. Find the drawdown in the observation well for a time period of

(i) 15 minutes

(ii) 20 hours

(6 marks)

(c) 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 Q1(c).** By using the Cooper-Jacob method, calculate

(i) Transmissivity,

(ii) Hydraulic conductivity,

(6 marks)

(d) A step test was carried out four hours steps. The **Table Q1(d)** shows the data obtained for yield (Q) and corresponding drawdown (s_w) in the pumping well. Predict

(i) Value of losses

(ii) Percent of well efficiency drops

(6 marks)

PART B

Q2 (a) Briefly define the followings:
(i) Aquifer
(ii) Porosity

(2 marks)

(b) Briefly explain **TWO (2)** importances of groundwater studies.

(4 marks)

(c) The annual water balance for a lake includes 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.

(6 marks)

(d) The change in inter-granular pressure at the bottom of the sand layer occurs with 40 m drops of water table. The sand layer is 60 m thick, water table is located at a depth of 10 m below the groundwater surface and clay is 25 m at the bottom layer. Justify with aids of sketch the groundwater profile for the new water table.

(8 marks)

Q3 (a) State **TWO (2)** importances of groundwater level monitoring.

(2 marks)

(b) Describe **TWO (2)** techniques that incorporate resistivity application and their purposes.

(4 marks)

(c) A river and a canal run parallel to each other L= 500 m apart as shown in **Figure Q3(c)** with fully penetrate an 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. Assumming no recharge, find the discharge into the river.

(6 marks)

(d) Surface water and groundwater systems are connected in most landscapes. Compare the conditions with aids of sketch for gaining and losing stream.

(8 marks)

Q4 (a) List **TWO (2)** groundwater flow characteristics in terms of groundwater movement.

(2 marks)

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

(i) the unit flow rate into the gallery

(ii) classify the type of soil (**Table Q4(c)**).

(6 marks)

(d) Derive **TWO (2)** relationships of the laboratory experiments as shown in **Figure Q4(d)** to Darcy's Law for hydraulic conductivity determination.

(6 marks)

Q5 (a) Briefly explain the term groundwater contamination.

(2 marks)

(b) Define **TWO (2)** categories of contamination sources and examples.

(4 marks)

(c) Groundwater remediation techniques are mainly divided into two technologies which include ex-situ and in-situ. Appraise the technologies that involved within each of the categories.

(6 marks)

(d) 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. Estimate by 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)

Q6 (a) List **TWO (2)** daily activities to protect and conserve groundwater.

(2 marks)

(b) Discuss on the water level fluctuation with aids of recharge equation.

(4 marks)

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

(6 marks)

(d) Conclude the process of groundwater recharge on the vadose zone soil water budget into three distinct processes.

(8 marks)

–END OF QUESTIONS–

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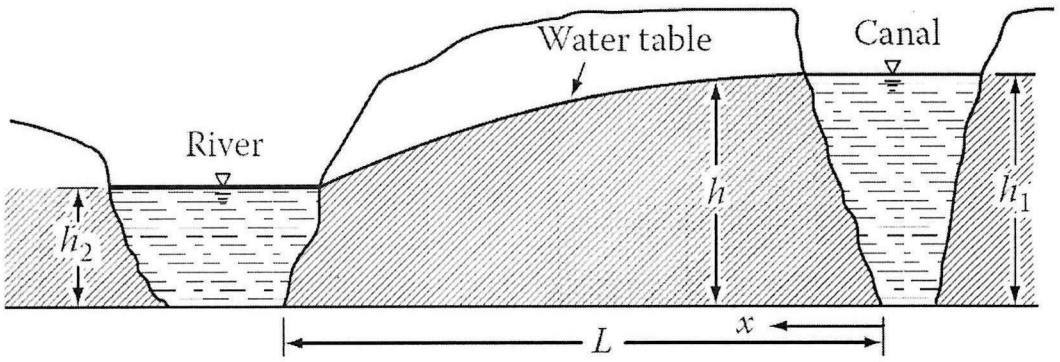

FIGURE Q3(c): Open channel cross-section

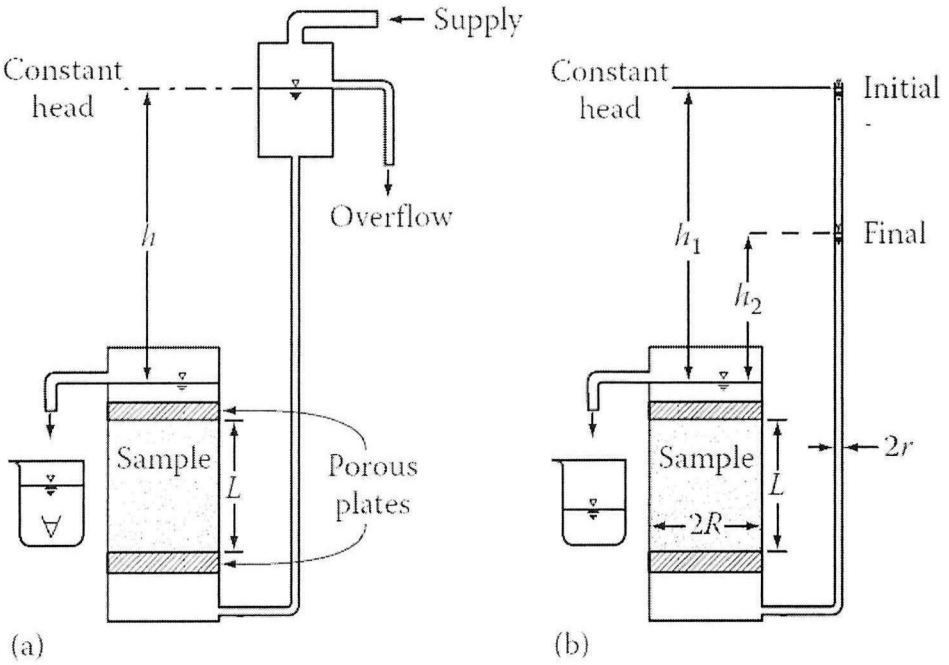

FIGURE Q4(d): Experimental samples

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Table Q1(c): 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 Q1(d): Pumping test

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

Table Q4(c): Hydraulic conductivity values

Material	K (cm/sec)
Gravel	10^{-1} to 100
Clean sand	10^{-4} to 1
Silty sand	10^{-5} to 10^{-1}
Silt	10^{-7} to 10^{-3}
Glacial till	10^{-10} to 10^{-4}
Clay	10^{-10} to 10^{-6}

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EQUATIONS

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

$$h^2 = c_1x + c_2$$

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

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

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

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

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

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

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