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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2014/2015

COURSE NAME	:	GROUNDWATER ENGINEERING
COURSE CODE	:	BFW 40403
PROGRAMME	:	4 BFF
EXAMINATION DATE	:	DECEMBER 2014/JANUARY 2015
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

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

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Q1 (a) Briefly define the following with the aid of sketches.

(i) Unconfined Aquifer
(ii) Confined Aquifer
(iii) Groundwater table
(iv) Head of groundwater

(4 marks)

(b) Discuss **THREE (3)** reasons why groundwater in Malaysia is not fully utilized.

(9 marks)

(c) During one year, the water balance terms for a lake included rainfall P = 1100 mm/year, evaporation E = 720 mm/year, surface inflow I = 55 mm/year, surface outflow O = 135 mm/year, and change in storage ΔS = 60 mm/year. Calculate the net groundwater flow for the lake.

(12 marks)

Q2 (a) Calculate the flow rate (in m^3/day) through an aquiclude, with the following parameters obtained from a laboratory experiment:

Sample column size = 15 cm diameter and 30 cm long
Head difference between manometers Δh = 5 cm
Hydraulic conductivity $K = 2.85 \times 10^{-7}$ cm/s

(6 marks)

(b) A cylindrical field sample of an unconfined aquifer with length of 60 cm and diameter of 20 cm is tested for a period of 10 minutes under a constant head difference of 15 cm. The pore diameter and effective porosity is found to be 0.037 cm and 0.1, respectively. If the hydraulic conductivity K is 1.736×10^{-3} cm/min,

(i) Categorize the type of aquifer material based on **Table 1**.

(5 marks)

(ii) Determine the applicability of Darcy's law if dynamic viscosity and density of water are 1.005×10^{-3} kg/ms and 998.2 kg/m^3, respectively.

(10 marks)

(iii) Compute the volume of water (in litre) collected at the outlet of the test apparatus.

(4 marks)

Q3 (a) Derive the Theim equations for unconfined and confined aquifers in steady radial flow conditions.

(6 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 m 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/s for 400 min. Drawdown measured at an observation well located 200 m away is given in **Table 2**. Using the Cooper-Jacob method, calculate:

(i) Transmissivity (m^2/s)
(ii) hydraulic conductivity (m/s)
(iii) storativity

(13 marks)

Q4 (a) List the boundary conditions of groundwater flow model in Figure **Q4**. Provide justification for the selection of boundary conditions.

(5 marks)

(b) Find the permeability of an artesian unconfined aquifer that is being pumped by a fully penetrating well. The steady state pumping rate is 300 m^3/hr. The drawdown at an observation well 50 m away is 40 m whilst in a second observation well 100 m away is 43 m. Also, sketch the section view of wells and the complete groundwater profile.

(12 marks)

(c) After a period of pumping at a rate of 120 $m^3/hour$, the drawdowns in observation wells 15 m and 30 m distance away the pumped well are found to 1.0 m and 0.75 m, respectively. Determine the transmissivity of the aquifer.

(8 marks)

Q5 (a) Explain briefly the suitable methods for drilling of shallow and deep wells.
(4 marks)

(b) Discuss the mechanism of electrical imaging resistivity method for detecting groundwater contamination.
(8 marks)

(c) A 0.46 m diameter well is used to pump water from a confined aquifer at 0.38 m^3/min. The drawdown recorded at observation wells located at 15.24 m and 60.96 m away from the pumping well are 3.05 m and 2.44 m, respectively. Determine

(i) Transmissivity of the aquifer.
(ii) Drawdown at the pumping well.

(13 marks)

- END OF QUESTION –

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TABLE 1

Typical Values of Hydraulic Conductivity

Material	Hydraulic conductivity (m/day)
Gravel, coarse	150
Gravel, medium	270
Gravel, fine	450
Sand, coarse	45
Sand, medium	12
Sand, fine	2.5
Silt	0.08
Clay	0.0002
Sandstone, fine-grained	0.2
Sandstone, medium-grained	3.1
Limestone	0.94
Dolomite	0.001
Dune sand	20
Loess	0.08
Peat	5.7
Schist	0.2
Slate	0.00008
Till, predominantly sand	0.49
Till, predominantly gravel	30
Tuff	0.2
Basalt	0.01
Gabbro, weathered	0.2
Granite, weathered	1.4

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TABLE 2

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

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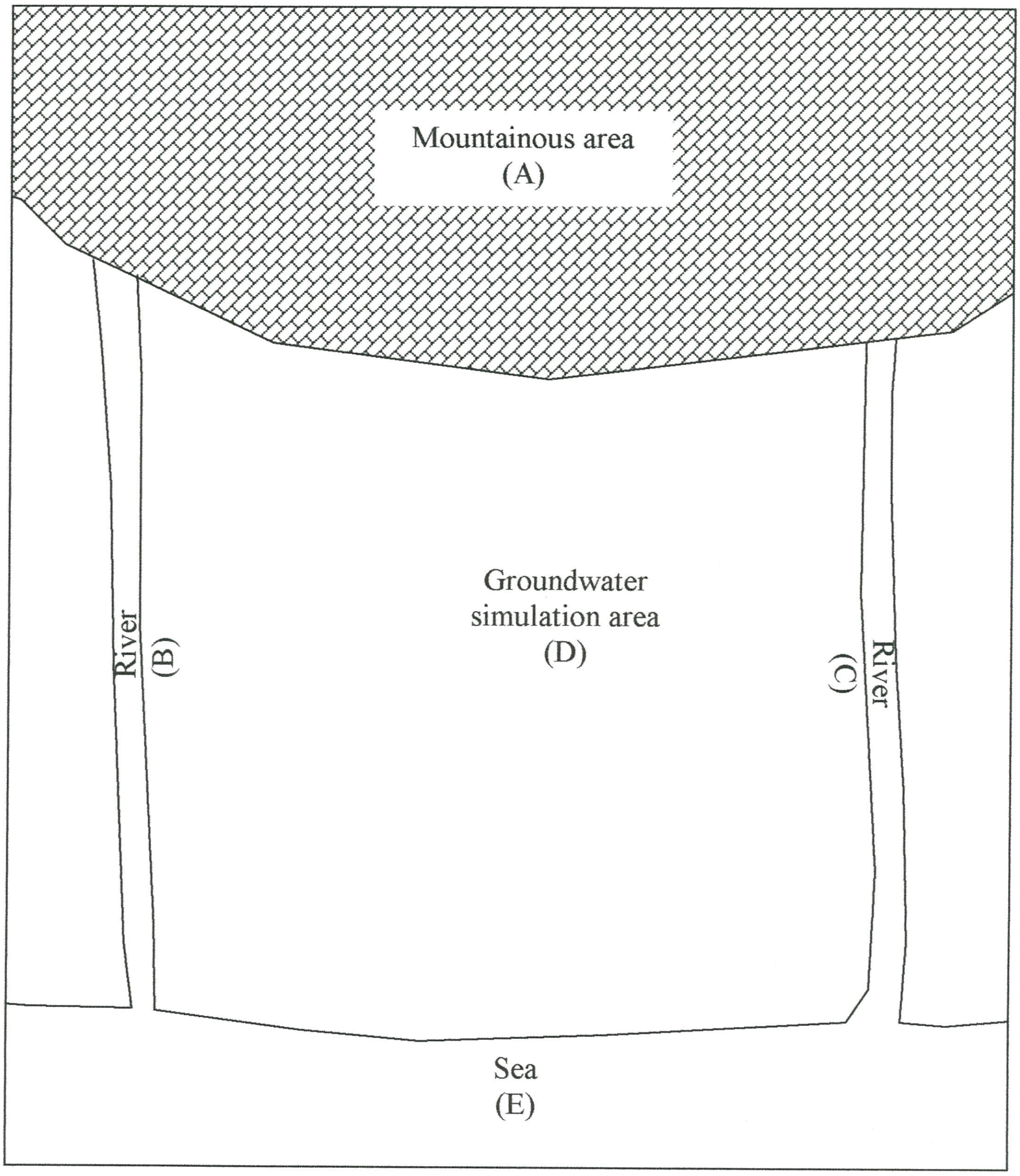

FIGURE Q4

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Supplementary Equations

$$\text{Re} = \frac{\rho VD}{\mu}$$

$$K = \frac{Q}{\pi\left(h_2^2 - h_1^2\right)} \ln\left(\frac{r_2}{r_1}\right)$$

$$T = \frac{Q}{2\pi\left(h_2 - h_1\right)} \ln\left(\frac{r_2}{r_1}\right)$$

$$\text{T} = \frac{2.3\text{Q}}{4\pi\Delta s'}$$

$$S = \frac{2.25Tt_o}{r^2}$$