National Exams December 2016

04-Geol-A2, Hydrogeology

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is an OPEN BOOK EXAM.
   Any non-communicating calculator is permitted.
3. FIVE (5) questions constitute a complete exam paper.
4. Each question is of equal value.
5. Most questions require an answer in essay format. Clarity and organization of the answer are important. Please show your work.
6. Unless otherwise specified, use water density = 1000 kg/m^3, water viscosity = 0.001 kg/m-sec, and g = 9.81 m/s^2.

Question 1

a) Calculate the Darcy velocity in meters per second for a hydraulic conductivity of 10^{-6} m/s and a hydraulic gradient of 100 ft/mile.
b) Calculate the seepage velocity in meters per second from question 1a) for an effective porosity of 0.1.
c) A constant head permeameter (see Figure 1) has a cross-section area of 225 cm^2. The soil sample is 25 cm long. At a head of 15 cm, the permeameter discharges 50 cm^3 in 456 s. What is they hydraulic conductivity in cm/s? What is the intrinsic permeability? □

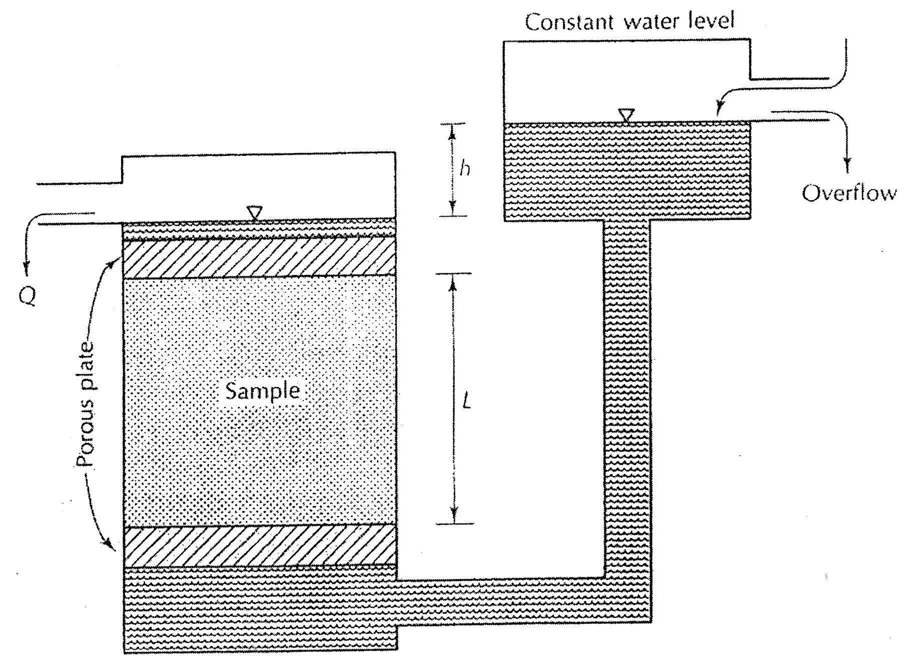
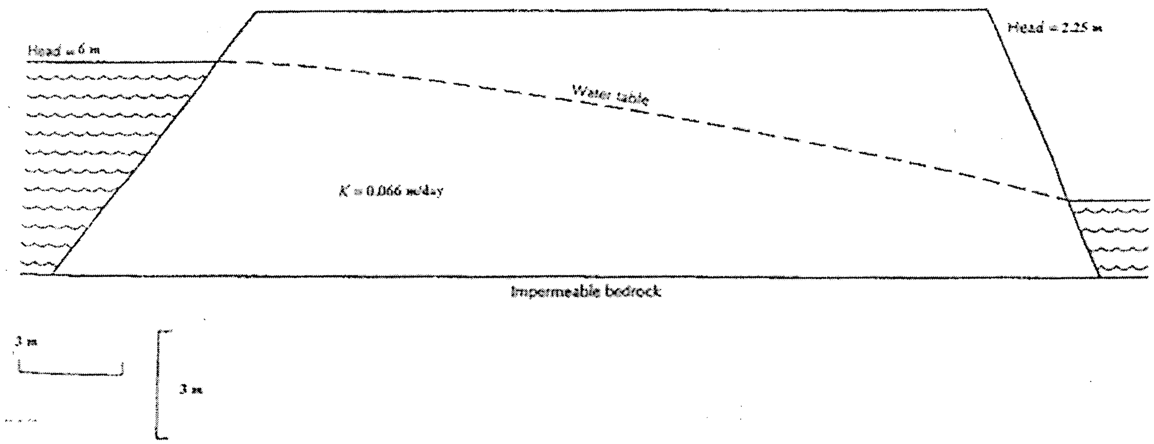


Figure 1: Constant head permeameter

d) An unconfined aquifer with a storativity of 0.23 has an area of 3.2×10^8 m^2. During a drought, the water table drops 1.5 m. How much water is lost from storage? □□
e) The volume of water lost from storage of a confined aquifer is 200,000 m^3. Given that the area is 3.2×10^8 m^2 and the storativity is 0.0005, what is the change in head that corresponds to this loss?

Question 2

a) Draw the flow net for seepage through the earthen dam shown below.



b). If the hydraulic conductivity of the material is 0.066 m/day, what is the seepage per unit width per day?

Question 3

Three geological formations, each 25 m thick, overlie on another. The hydraulic conductivity of the top formation s 0.001 m/s, the middle formation is 0.005 m/s and the bottom formation is 0.001 m/s.

a) If a constant-velocity vertical flow field is set up across the set of formations with the hydraulic head of 200 m at the top and hydraulic head of 80 m at the bottom, calculated hydraulic heads at the two internal boundaries (between the formations).
b) What are the water pressure heads at the boundaries?

Question 4
A community is planning a new subdivision which will use well water as their main domestic water source. The aquifer they are planning to use is a confined aquifer with a transmissivity of 248 m^2/day and a storativity of 0.0002.

a) Compute the drawdown caused by the new pumping well at 50 m and 150 m, if the pumping rate is 2.8 m^3/min, and the pump is continuously pumping for 30 days.
b) If the aquifer is not fully confined but is overlain by a 3 m confining layer with a vertical hydraulic conductivity of 0.05 m/day, and no storativity, what would be the drawdown after 30 days at 50 and 150 m (assume same pumping rate).

Question 5
a) What are the advantages and disadvantages of using geophysics, remote sensing, mapping, and borehole investigations for groundwater exploration? List two advantages and two disadvantages for each method.
b) List three methods to determine the hydraulic conductivity of soil at a site.
c) Discuss the advantages and disadvantages of slug tests compared to pump tests. List two advantages and two disadvantages.

Table 5.1
Values of $W(u)$ for values of u (from Wenzel, 1942)

u	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
$\times 1$	0.219	0.049	0.013	0.0038	0.0011	0.00036	0.00012	0.000038	0.000012
$\times 10^{-1}$	1.82	1.22	0.91	0.70	0.56	0.45	0.37	0.31	0.26
$\times 10^{-2}$	4.04	3.35	2.96	2.68	2.47	2.30	2.15	2.03	1.92
$\times 10^{-3}$	6.33	5.64	5.23	4.95	4.73	4.54	4.39	4.26	4.14
$\times 10^{-4}$	8.63	7.94	7.53	7.25	7.02	6.84	6.69	6.55	6.44
$\times 10^{-5}$	10.94	10.24	9.84	9.55	9.33	9.14	8.99	8.86	8.74
$\times 10^{-6}$	13.24	12.55	12.14	11.85	11.63	11.45	11.29	11.16	11.04
$\times 10^{-7}$	15.54	14.85	14.44	14.15	13.93	13.75	13.60	13.46	13.34
$\times 10^{-8}$	17.84	17.15	16.74	16.46	16.23	16.05	15.90	15.76	15.65
$\times 10^{-9}$	20.15	19.45	19.05	18.76	18.54	18.35	18.20	18.07	17.95
$\times 10^{-10}$	22.45	21.76	21.35	21.06	20.84	20.66	20.50	20.37	20.25
$\times 10^{-11}$	24.75	24.06	23.65	23.36	23.14	22.96	22.81	22.67	22.55
$\times 10^{-12}$	27.05	26.36	25.96	25.67	25.44	25.26	25.11	24.97	24.86
$\times 10^{-13}$	29.36	28.66	28.26	27.97	27.75	27.56	27.41	27.28	27.16
$\times 10^{-14}$	31.66	30.97	30.56	30.27	30.05	29.87	29.71	29.58	29.46
$\times 10^{-15}$	33.96	33.27	32.86	32.58	32.35	32.17	32.02	31.88	31.76

Table 5.2
Values of $W(u\ r/B)$ (after Hantush, 1956)*

u \ r/B	0.01	0.015	0.03	0.05	0.075	0.10	0.15	0.2	0.3	0.4
0.000001										
0.000005	9.4413									
0.00001	9.4176	8.6313								
0.00005	8.8827	8.4533	7.2450							
0.0001	8.3983	8.1414	7.2122	6.2282	5.4228					
0.0005	6.9750	6.9152	6.6219	6.0821	5.4062	4.8530				
0.001	6.3069	6.2765	6.1202	5.7965	5.3078	4.8292	4.0595	3.5054		
0.005	4.7212	4.7152	4.6829	4.6084	4.4713	4.2960	3.8821	3.4567	2.7428	2.2290
0.01	4.0356	4.0326	4.0167	3.9795	3.9091	3.8150	3.5725	3.2875	2.7104	2.2253
0.05	2.4675	2.4670	2.4642	2.4576	2.4448	2.4271	2.3776	2.3110	1.9283	1.7075
0.1	1.8227	1.8225	1.8213	1.8184	1.8128	1.8050	1.7829	1.7527	1.6704	1.5644
0.5	0.5598	0.5597	0.5596	0.5594	0.5588	0.5581	0.5561	0.5532	0.5453	0.5344
1.0	0.2194	0.2194	0.2193	0.2193	0.2191	0.2190	0.2186	0.2179	0.2161	0.2135
5.0	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011

u \ r/B	0.5	0.6	0.7	0.8	0.9	1.0	1.5	2.0	2.5
0.000001									
0.000005									
0.00001									
0.00005									
0.0001									
0.0005									
0.001									
0.005									
0.01	1.8486	1.5550	1.3210	1.1307					
0.05	1.4927	1.2955	1.2955	1.1210	0.9700	0.8409			
0.1	1.4422	1.3115	1.1791	1.0505	0.9297	0.8190	0.4271	0.2278	
0.5	0.5206	0.5044	0.4860	0.4658	0.4440	0.4210	0.3007	0.1944	0.1174
1.0	0.2103	0.2065	0.2020	0.1970	0.1914	0.1855	0.1509	0.1139	0.0803
5.0	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0010	0.0010	0.0009

*Trans. Amer. Geophys. Union, 37, p. 702–714. Copyright by Amer. Geophys. Union.