M.E. (Water Resources and Hydraulic Engineering) EXAMINATION, 2018

(First Year-2nd Semester)

Groundwater Dynamics

Time: Three hours Full Marks: 100

Answers any five

1. (a) Derive the governing equation for the two dimensional flow in an confined aquifer of a homogenous fluid in anisotropic homogenous porous media based on Dupuit approximation.

(b) A confined aquifer composed of a dense sandy-gravel matrix is 20 m thick and has a porosity of 0.3. If the compressibility co-efficient of water and solid matrix of the aquifer material is estimated to be 8×10^{-9} m^2/kN and 1×10^{-8} respectively, estimate the storage coefficient of the aquifer. Compare your result with the empirical equation. Assume $\gamma = 9790$ Ns/m^2. (16+4)=20

2. (a) Deduce the governing equation for radial flow in an unconfined steady, homogenous and isotropic aquifer.

(b) A two-layered soil system consists of horizontal layers that are each 6 m. Beneath the fine silt layer (k_2 equals 10^{-8} m/s) is a stratum of water-bearing gravel with a water pressure of 155 kN/m^2. The surface of the sand (k_1 equals 10^{-7} m/s) is flooded with water to a depth of 1 m. Determine the quantity of flow per unit area.

(15+5)=20

3. a) Why Copper-Jacob straight line method is advantageous over the Thies method? State its limitation.

(b) A well penetrating a confined aquifer is pumped at a uniform rate of 2500 m^3/day. Drawdowns during the pumping period are measured in an observation well 60 m away, observations of 't' and 's' are listed below in a tabulated form.

Time, t(min)	s(m)	Time, t (min)	s(m)
0	0	24	0.72
1	0.020	30	0.76
1.5	0.27	40	0.81
2.0	0.30	50	0.85
2.5	0.34	60	0.90
3.0	0.37	80	0.93
4.0	0.41	100	0.96
5.0	0.45	120	1.00
6	0.48	150	0.104
8	0.53	180	1.07
10	0.57	210	1.10
12	0.60	240	1.12
14	0.63		
18	0.67		

The well function W(u) and u are also given in a tabular form

u	1	10^{-1}	10^{-2}	10^{-3}
W(u)	0.219	1.82	4.04	6.33

Calculate transmissivity and Storativity of the confined aquifer using Theis Method.

(4+16)=20

4. (a) In a test of a confined aquifer, the pumping rate was 500 m^3/day. Drawdown and time data were collected at an observation well 300 m away (table given below). Determine the transmissivity and storativity of the aquifer using the Copper-Jacob Straight Line Method.

Table: Drawdown measured at an observation well 300 m away

Time(min)	S(m)	Time(min)	S(m)
1.00	0.03	35.62	1.79
1.27	0.05	45.20	1.97
1.61	0.09	57.36	2.15
2.04	0.15	72.79	2.33
2.59	0.22	92.37	2.52
3.29	0.31	117.21	2.70
4.18	0.41	148.74	2.89
5.30	0.53	188.74	3.07
6.72	0.66	239.50	3.26
8.53	0.80	303.92	3.45
10.83	0.95	385.66	3.64
13.74	1.11	489.39	3.83
17.43	1.27	621.02	4.02
22.12	1.44	788.05	4.21
28.07	1.61	1000.00	4.39

(b) Prove that drawdown (s) can be expressed by "Copper-Jacob Method" is

$$s = \frac{2.3Q}{4\pi T} log \frac{2.25Tt}{r^2 S}$$

where Q is the discharge of pumping well, T and S are the Transmissivity and Storativity with time 't' and r is the radial distance between main well to observation well.

15+5=20

5. (a) A 30 cm well was pumped at a uniform rate of 2500 m^3/day. The pump was shut down after 240 min. The pumping was stopped and the residual drawdowns during recovery in different time are given in Table below. Determine the transmissivity "T".

Recovery time t' (min)	Residual drawdown s' (m)	Recovery time t' (min)	Residual drawdown s' (m)
1	0.89	30	0.38
2	0.81	40	0.34
3	0.76	60	0.28
5	0.68	80	0.24

7	0.64	100	0.21
10	0.56	140	0.17
15	0.49	180	0.14
20	0.55		

(b) Show that equation which describes the transient drawdown in the piezometric head caused by a fully penetrating pumping well in a confined aquifer

$$s(u) = \frac{Q_w}{4\pi T}\int_u^{\infty} \frac{e^{-u}}{u}\,du$$

(12+8)=20

6. (a) What are the factors depends on coefficient of permeability in case of porous material? Name two methods to determine the coefficient of permeability in the laboratory by a permeameter. Deduce an expression the coefficient of permeability for fined grained soils.

(b) Derive the functional relationship between the hydraulic conductivity and the fluid and solid-matrix properties using dimensional analysis.

(c) A sand aquifer has a 15-percentile particle size of 0.85 mm and an effective porosity of 0.45. If the temperature of the water in the aquifer is 17^0C, estimate the range of seepage velocities for which Darcy's law is valid. Assume $\mu = 0.032$ N-s/m^2.

(8+8+4)=20

7. (a) Groundwater flows through a buried-valley aquifer with a cross-sectional area of 105 m^2 and length of 6116 m. Hydraulic heads at the ground-water entry and exit points in the aquifer are 306 m and 294 m respectively. At the downstream end of the aquifer, groundwater discharges into a stream at a rate of 2857 m^3/day. What is the hydraulic gradient?

(i) 0.002 (ii) 0.004 (iii) 0.006 (iv) 0.008

b) An intrinsic permeability of 100 darcys, a temperature of 20^0C (dynamic viscosity=0.001 Ns/m^2, specific weight = 9790 N/m^3), what is the hydraulic conductivity?

(i) 63.7 m/d (ii) 83.7 m/d (iii) 93.7 m/d (iv) 33.7 m/d

c) The specific discharge of the aquifer is found to be 0.32 m/d and it is to be travelled from one point to another point covering a distance of 1 km with effective porosity of 0.2, what is pore ground water velocity?

(i) 2.0 m/day (ii) 1.6 m/day (iii) 0.16 m/day (iv) 0.2 m/day

d) By considering the above problem 'c', what is the travel time from one point to another point to reach water?

(i) 2.0 years (ii) 2.5 years (iii) 3.0 years (iv) 3.5 years

e) A 609.6 mm diameter well is installed in a confined aquifer using a 152.4 mm gravel pack. The aquifer has a transmissivity of 879 m^2/d, and the well is pumped at a rate of 500 m^3/d. If the radius of influence of the well is 150 m, determine the steady-state drawdown at the well.
(i) 0.77 m (ii) 0.87 m (iii) 0.97 m (iv) 1.07 m

f) What is the well function 'W(u)', if 'u' is a dimensionless term to be estimated as 1.01×10^{-10}? Assume neglecting second and higher order terms.
(i) 22.44 (ii) 32.44 (iii) 42.44 (iv) 52.44

g) For the well, determine the 'u' value at the well where radius of well and the radial distance are 304.8 mm and 1000 mm respectively after 1 year of pumping at a rate of 500 m^3/d with a transmissivity of the aquifer of 879 m^2/d. The storage co-efficient of the aquifer is 0.00035.
(i) 1.53×10^{-11} (ii) 2.53×10^{-11} (iii) 3.53×10^{-11} (iv) 4.53×10^{-11}
h) If W(u) value is found to be 32.84, determine the drawdown at the well in case of unsteady-state confined aquifer. The well is being pumped at a rate of 500 m^3/d with a transmissivity of the aquifer of 879 m^2/d.
i) 1.5 m ii) 2.5 m iii) 3.5 m iv) 0.5 m

i) During a falling head permeability test, the initial head at t_1=30 min is 80 cm. At t_2=60 min, the head is 75 cm. The diameter of the standpipe and the specimen are 1.5 cm and 20 cm, respectively. The length of the specimen is 30 cm. Determine the hydraulic conductivity of the specimen.

(j) 6.04×10^{-8} m/s (ii) 7.04×10^{-5} m/s (iii) 6.04×10^{-5} m/s (iv) 7.04×10^{-8} m/s

J) What is the entrance velocity, the if the well discharge, clogging coefficient, screen diameter, screen length and the percentage of open area in the screen are 50 m^3/h, 0.5, 100 mm, 20 m and 60% respectively?

(k) 0.0074 m/s (ii 0.074 m/s (iii) 0.0094 m/s (iv) 0.094 m/s

(2x10)=20